THE JOURNAL
Volume 18, No. 9
pp. 259-288

CERAMIC ABSTRACTS
Volume 14, No. 9
pp. 205-236

AMERICAN CERAMIC SOCIETY

SEPTEMBER • 1935

MONTHLY PUBLICATIONS DEVOTED TO THE ARTS AND SCIENCES RELATED TO THE SILICATE INDUSTRIES

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Publication Office: 20th and Northampton Sts., Easton, Pa.

Entered as second-class matter at the post office at Easton, Pa., under the Act of March 3, 1879.
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Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
(Foreign and Canadian postage, 50c additional on subscriptions)

TALC IN WHITEWARE BODIES OF THE WALL-TILE TYPE*

By R. F. Geller and A. S. Creamer

Abstract

Effects of MgO and of CaO, introduced as a lime-free talc and as a lime-bearing "tremolite" talc, in whiteware heated at four temperatures were investigated. The results indicate that (1) in earthenware bodies, 40% or less of talc may be expected to increase porosity slightly and materially decrease shrinkage, (2) thermal expansion may be greatly affected by small variations in the amount of talc used, the temperature of heating, and the percentage of CaO, and (3) talc has a beneficial effect on resistance to moisture crazing.

I. Introduction

This investigation was limited to studies of mixtures containing from 0 to 14.4% of MgO and 72.0 to 74.8% of SiO_2 in the matured, or anhydrous, state as determined by calculations based on chemical analyses of the batch constituents. A maximum of 43% of talc was used to prepare the batch mixtures. Such properties were investigated as are believed to be of greatest importance to the manufacturer of ceramic whiteware. Particular effort was made to determine why industrial experiments with glazed bodies containing relatively low percentages of talc had improved the product in some cases but in others had caused extremes of either shivering or crazing.

II. Talcs Examined

Producers and users of talc submitted thirteen samples. Six fairly distinct types were represented and may be described as follows:

(1) Mined in California and sometimes erroneously referred to as "amorphous"; this material is composed largely (60 to 75%) of particles of well-defined cleavage having indices of refraction between 1.60 and 1.63 and which are probably tremolite ($CaO \cdot 3MgO \cdot 4SiO_2$). The remainder is mostly talc ($3MgO \cdot 4SiO_2 \cdot H_2O$), the percentage of calcite ($CaCO_3$) being estimated as less than one.

(2) Also mined in California, but over 90% is composed of finely divided platy particles having the correct indices of refraction for talc; a trace of CaO was noted.

(3) Mined in California and appears, microscopically, to contain at least 90% of pure talc in finely divided platy particles; resembles type (2) but is higher in Fe_2O_3 and contains a measurable quantity of CaO.

(4) From northern New York and like type (1) of the "tremolite variety." It is characterized by comparatively long fibers, the calcite is estimated as 3 to 4%; about 1/3 is talc, and the remainder is tremolite and probably other minerals of the amphibole group.

(5) Imported from Manchuria and resembles types (2) and (3) in general appearance, although an appreciable portion of the particles (25 to 30%) is in the form of "droplets" of very low birefringence, probably spherulitic; it has the average index of refraction of talc.

(6) A French material containing 10 to 15% of calcite, at least 75% of talc, and apparently no tremolite. The sample contains small amounts of the low birefringent particles found in sample (5) and at least one other unidentified phase.

One sample of each of the first five types was analyzed chemically and the results are given in Table I.

Table I

Chemical Composition of Five Samples of Commercial Talc and the Particle-Size Distribution, by Count, in the Two Samples Used

(a)

No.	Source	MgO (%)	CaO (%)	SiO_2 (%)	Ignition loss (%)	R_2O_3 (%)	
1	California	27.9	8.0	58.5	4.5	1.1	(mostly Al_2O_3)
2	"	31.3	tr.	61.9	5.3	1.3	(Fe_2O_3 0.85%, TiO_2 none)
3	"	31.7	0.3	61.3	5.4	1.2	(Fe_2O_3 estimated higher than in No. 2)
4	New York	30.5	6.9	55.9	5.4	1.3	(mostly Al_2O_3)
5	Manchuria	32.3	tr.	61.3	5.8	0.7	(practically all Al_2O_3)

(b)

No. 2 (talc T, containing practically no fibers)		No. 4 (talc A)	
Maximum dimension (μ)	Amount (%)	Maximum dimension, long fibers: (μ)	Amount (%)
20	tr.	35	1
15	1	Short fibers and particles: (μ)	
10	2		
5	7		
<5	90	5	4
		<5	95

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (White Wares Division). Received May 14, 1935.

Publication approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce.

III. Materials Used

Two of the samples analyzed were selected and used as representative of the lime-free and lime-bearing types, respectively. Talc No. 2 in Table I was designated T (for lime-free mineral talc), which letter identifies also all bodies containing this talc. Talc No. 4 in Table I, as well as each body containing it, is identified by the letter A (for lime-bearing amphibole). These clays had been washed through No. 325 sieves and the feldspar and flint had been re-ground to obtain a product of 35μ maximum diameter.

MgO and $Ca(OH)_2$ of reagent quality were used in preparing five special bodies.

IV. Methods

The bodies of Group 1 (Table II) were designed to show the relative effect of the partial, or entire,

TABLE II

BATCH COMPOSITIONS AND THE CALCULATED CHEMICAL COMPOSITIONS OF THE HEATED BODIES

Body	Calculated chemical composition (%) MgO Series		CaO Series		R_2O_3 Series		R_2O_3[d]		SiO_2 Series		K_2O+Na_2O Both series	Batch compositions (%) Talc[b]	Feldspar	Ball clay	Kaolin	Flint	MgO
	T	A	T	A	T		A		T	A							
B[c]					23.9				74.8		1.3		8.0	25.0	30.0	37.0	
Group 1[d]																	
1					24.2				75.0		0.8		5.0	25.8	31.0	38.2	
2					24.4				75.6					27.2	32.6	40.2	
3	1.7	1.7	0.4	0.4	23.3	22.9	75.0	75.0				5.0		25.8	31.0	38.2	
4	0.9	0.8	0.2	0.2	23.7	23.6	75.0	75.0			0.4	2.5	2.5	25.8	31.0	38.2	
5	1.4	1.3	0.3	0.3	23.1	23.3	74.8	74.4			0.7	4.0	4.0	25.0	30.0	37.0	
Group 2[e]																	
6	3.0	3.0	0.7	0.7	22.2	21.9	74.8	74.4				8.8		25.1	29.8	36.3	
7	2.8	2.8	0.6	0.6	21.8	21.6	74.8	74.4			0.65	8.3	4.0	23.7	28.1	35.9	
8	5.4	5.3	1.2	1.2	19.8	19.7	74.8	73.8				15.9		22.4	26.5	35.2	
9	5.1	5.0	1.1	1.1	19.5	19.5	74.8	73.8			0.58	15.1	3.5	21.3	25.3	34.8	
10	10.3	10.0	2.3	2.3	14.9	14.8	74.8	72.9				30.3		24.6	13.6	31.5	
11	9.9	9.6	2.2	2.2	14.9	14.9	74.8	72.9			0.44	29.1	2.7	23.7	13.1	31.4	
12	12.3	12.0	2.7	2.7	12.9	12.8	74.8	72.5				36.4		24.2	8.8	30.6	
13	11.5	11.2	2.5	2.5	13.0	13.0	74.8	72.6			0.75	34.2	4.6	22.6	8.2	30.4	
14	14.4	14.1	3.2	3.2	10.8	10.7	74.8	72.0				43.0		20.0	7.2	29.8	
M 6	3.0				22.2		74.8							25.2	29.9	42.0	2.9
M 10	10.3				14.9		74.8							25.1	13.9	51.3	9.7
M 14	14.4				10.8		74.8							20.6	7.5	58.1	13.8
TC 10	10.1		2.3		14.6		73.0					100 parts body T 10 + 3.1 parts $Ca(OH)_2$					
MC 10	10.1		2.3		14.6		73.0					100 parts body M 10 + 3.1 parts $Ca(OH)_2$					

[a] Maximum Fe_2O_3 is 0.6% in body T 14; maximum TiO_2 is 0.8% in body B.

[b] Talc T used in bodies of series T, and talc A in bodies of series A; for compositions of these talcs see Table I.

[c] Body B is the basic or reference body for both groups and was selected as typical of the commercial wall-tile body.

[d] In all bodies of this group, the ratios of ball clay, kaolin, and flint to each other are the same as in body B; since no talc was used in bodies 1 or 2, they do not belong to either series.

[e] The bodies of series T in this group were designed to have the same total SiO_2 content as body B; in bodies of series A, the CaO + SiO_2 is practically equal to the total SiO_2 in series T and body B; in bodies M 6, M 10, and M 14, the MgO was introduced as magnesia and bodies TC 10 and MC 10 are bodies T 10 and M 10 modified to approximate body A 10 in composition.

two talcs were used as received, their finely divided state and freedom from coarse particles (Table I) precluding any necessity for washing or sieving.

The ball clay (Kentucky No. 4), kaolin (Georgia "soft"), potash feldspar, and "potter's flint" (crushed quartz) were portions of the same materials used in a previous investigation, and their chemical compositions have been reported.[1] The elimination of feldspar and the partial substitution of talc on the weight basis. For this reason the ratios of ball clay, kaolin, and flint to each other are the same as in the base (or control) body B. The values for these bodies are meant to serve as references in evaluating the effects of talc and of feldspar in the bodies of group 2.

The batch compositions of the bodies of group 2 (Table II) were calculated to give a series of compositions which, after heating, would contain varying amounts of MgO and of CaO but practically constant total SiO_2, approximating the total SiO_2 content of the heated base body B.

[1] R. F. Geller, D. N. Evans, and A. S. Creamer, "Effect of Particle Size of a Potter's 'Flint' and a Feldspar in Whiteware," *Bur. Stand. Jour. Research*, **11**, 327 (1933); R. P. 594; *Ceram. Abs.*, **12** [12] 427 (1933).

Bodies were prepared by agitating 400 grams of batch material in 1 liter of water for 2 hours, drying the resulting slip in plaster, and then crushing to pass a No. 30 sieve. This material was mixed thoroughly with 10 to 15% of water (the percentage decreasing with increase in talc content of the mixture), passed through No. 12 and No. 30 sieves successively, and pressed into tile measuring 2 by 2 by $^1/_4$ inch, using a pressure of 1450 pounds per square inch or approximately 100 kilograms per square centimeter. When dry, the tile were cut into "sticks," 2 by $^1/_4$ by $^1/_4$ inch, which were heated in a gas-fired kiln at one of each of four temperatures, namely, 1120, 1180, 1260, and 1325°C, and then used for determining water absorptivity, linear shrinkage, and moisture expansion.

The water absorptivity was calculated from the weights of specimens dry and after having been "autoclaved" for five hours at a steam pressure of 150 pounds per square inch while immersed in water.

The linear shrinkage, measured directly with a caliper, includes the total shrinkage during drying and heating and is expressed in percentage of the initial length.

The moisture expansion was determined by measuring specimens with a micrometer, reading to 0.0001 inch, before and after an autoclave treatment at 150 pounds per square inch for $1^1/_2$ hours, with the specimens immersed.

The reported values for absorptivity, shrinkage, and moisture expansion are the averages of five determinations.

True specific gravity was determined by the pycnometer method, using distilled water and material ground to pass a No. 200 sieve. The values reported are the averages of two determinations agreeing within ±0.001.

A portion of the material used in pressing tile was brought to a plastic consistency with additional water, and appropriate specimens were molded for thermal-expansion determinations by the interferometer method.

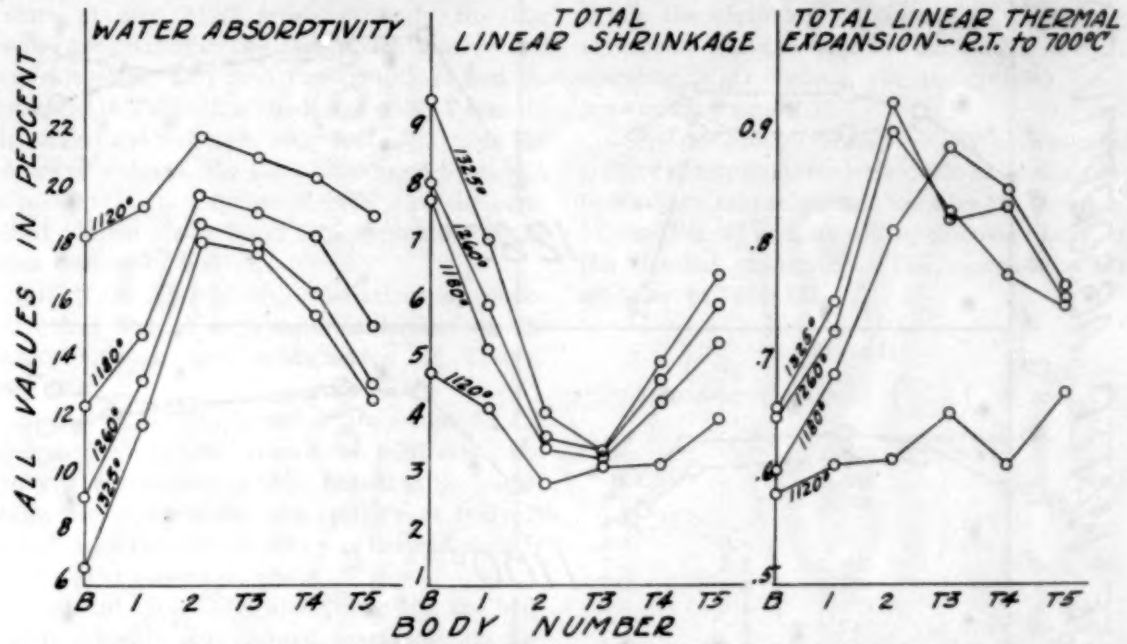

FIG. 1.—Plotted values for bodies of group 1 (Table II), illustrating some effects of eliminating feldspar and partly substituting talc in specimens heated at four temperatures.

V. Results

(1) Bodies of Group 1

Data for absorptivity, shrinkage, and thermal expansion are plotted in Fig. 1. Values for bodies A 3, A 4, and A 5 practically coincide with those for T 3, T 4, and T 5, and therefore are not shown. Summarized briefly, the data show that, weight for weight up to 5%, neither the lime-free nor the lime-bearing talc is as influential as potash feldspar in reducing absorp-

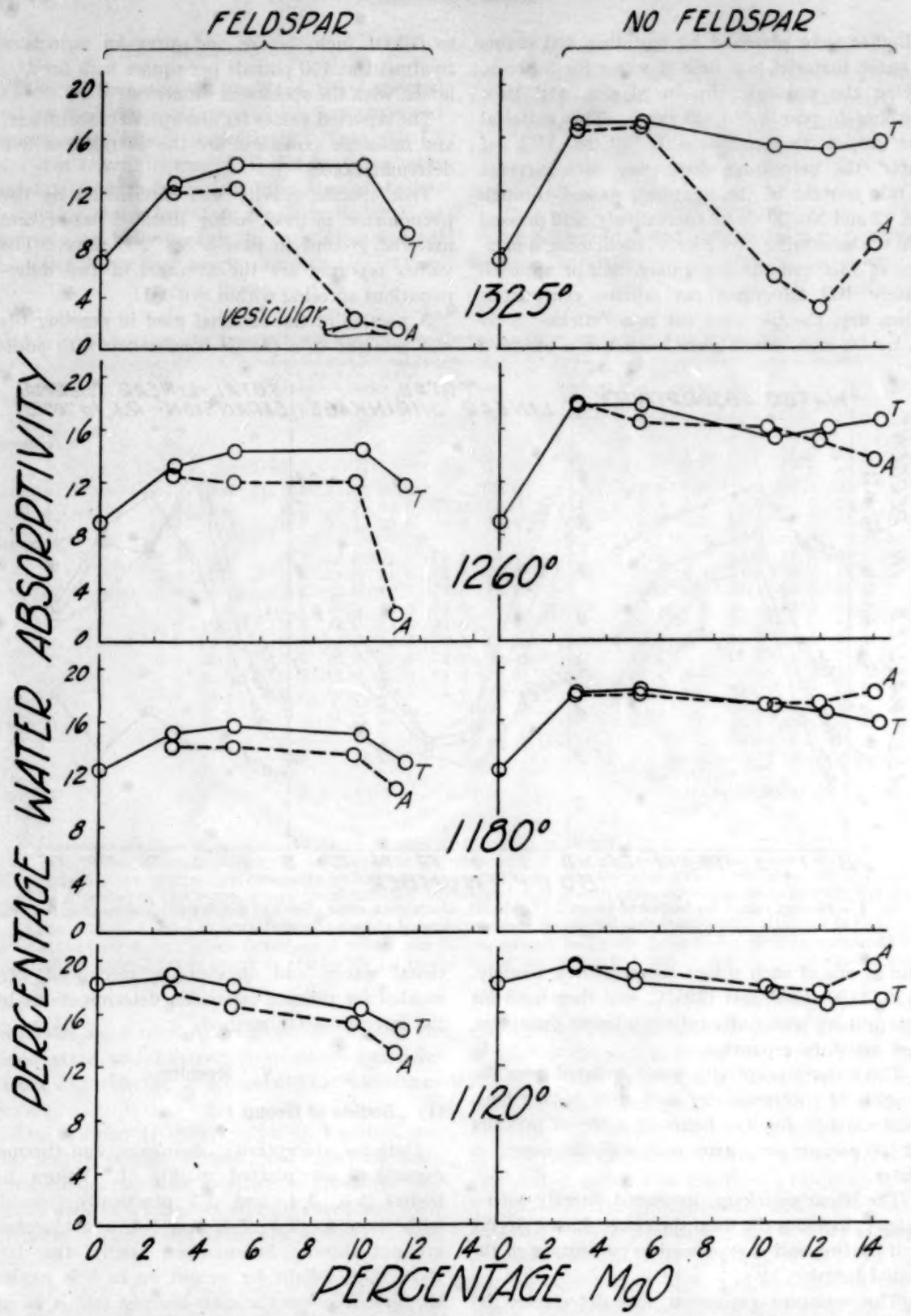

FIG. 2.—Water absorptivity of group 2 bodies heated at four temperatures. Curves identified by *T* connect values for bodies of series T containing the lime-free talc, and *A* identifies curves connecting values for the A series containing the lime-bearing talc. The values at 3% of MgO for the "no feldspar" compositions are for the body 6 (Table II) in which all the feldspar of the base body B (zero MgO) has been replaced by talc.

tivity, increasing shrinkage, or reducing thermal expansion. That the thermal expansion increases materially with decrease in feldspar (bodies B, 1 and 2) is ascribable to decreased solution of uncombined SiO_2; it is also in agreement with practical experience that "shivering" may be caused by reducing feldspar.

Moisture expansion will be discussed in connection with the bodies of group 2.

(2) Bodies of Group 2

In Figs. 2, 3, and 5, values for this group are plotted with respect to the MgO content, and values at zero MgO represent body B. The bodies are divided in two classes, feldspathic and nonfeldspathic, and into two series, T and A. As stated in Table II, all bodies of series T contain the same total SiO_2 as in body B (74.8%). In the bodies of series A, the CaO introduced by talc A is present at the expense of SiO_2, *i.e.*, the combined content of CaO and SiO_2 approximates the silica content of body B.

(*a*) *Water Absorptivity.*—Variations in composition had little, if any, significant effect on the absorptivity of specimens heated at 1120°C (Fig. 2).

Heated at 1180°C (approximately cone 5), the feldspar-free bodies remained relatively unchanged with respect to those heated at the lowest temperature, while the absorptivity of body B and of the feldspathic bodies was lowered slightly (4 to 6%) and averaged about 14%.

Heated at 1260°C (or about cone 10), the feldspar-free bodies still showed practically no differences due either to variations in composition or to the higher heat treatment. The same is true of the feldspathic bodies in the T series relative to the same bodies heated at 1180°C, but in the A series the body containing the highest percentage of MgO (and 2.5% CaO) absorbed only 2% of water. This is the nearest approach to vitrification, without the development of a vesicular structure, shown by any of the specimens investigated.

The heating at 1325°C (cones 12 to 13) produced not only a marked vesicular structure in the two feldspathic series A bodies of highest MgO content, but also increased significantly the effect of CaO in the bodies of series A containing no feldspar. The bodies of series T remained practically unchanged.

(*b*) *Linear Shrinkage.*—The curves of Fig. 3 show the general trends which one would expect after studying the absorptivity data. For bodies heated at 1120, 1180, and 1260°C, the shrinkage remained comparatively low with increased MgO up to approximately 10% (bodies T 11 and A 11), and then increased in the feldspathic group. For bodies of the A series, the effect of lime in increasing shrinkage was not pronounced, except for the bodies of highest MgO (and correspondingly high CaO) content heated at 1325°C.

In Fig. 3 there are plotted values for bodies M 6, M 10, and M 14 containing 3.0, 10.3, and 14.4% of MgO (Table II) added as magnesium oxide. While the shrinkage values are in satisfactory agreement with those for the talc bodies of corresponding MgO content, the absorptivity values were much greater.[3]

(*c*) *True Specific Gravity.*—Only such specific-gravity determinations were made as were needed to study certain relations shown by the shrinkage values (Fig. 4) and, as will be discussed later, by the thermal expansions. The complete results are given in Table III.

TABLE III

TRUE SPECIFIC GRAVITY $\left(\frac{25°C}{25°C}\right)$ OF BODIES

Body	MgO* (%)	Specimen heated at 1120°C	1180°C	1325°C
B	0	2.668		2.567
T 2	0	2.702		2.641
T 4	0.9		2.648	
A 4	0.8		2.659	
T 7	2.8	2.695		2.565
T 8	5.4	2.750		2.522
T 9	5.1	2.719		2.495
T 10	10.3	2.744	2.672	2.495
T 11	9.9		2.661	
A 11	9.6		2.561	
T 13	11.5	2.716		2.506
T 14	14.4	2.781	2.689	2.559
A 14	14.1		2.701	

* Values from Table II.

The application of true specific gravity values is illustrated by the T bodies of highest MgO content in the "no feldspar group," which undergo the greatest shrinkage when heated at the lowest temperature (Fig. 3). In the conventional whiteware body this would indicate overfiring. Here, however, such reactions as do occur between the ingredients apparently produce the maximum amount of glass and the greatest shrinkage at or below 1120°C. As the bodies are heated to higher

[3] For this reason they were not plotted in Fig. 2. It is possible that the absorptivity also would have been in agreement if fused MgO had been used.

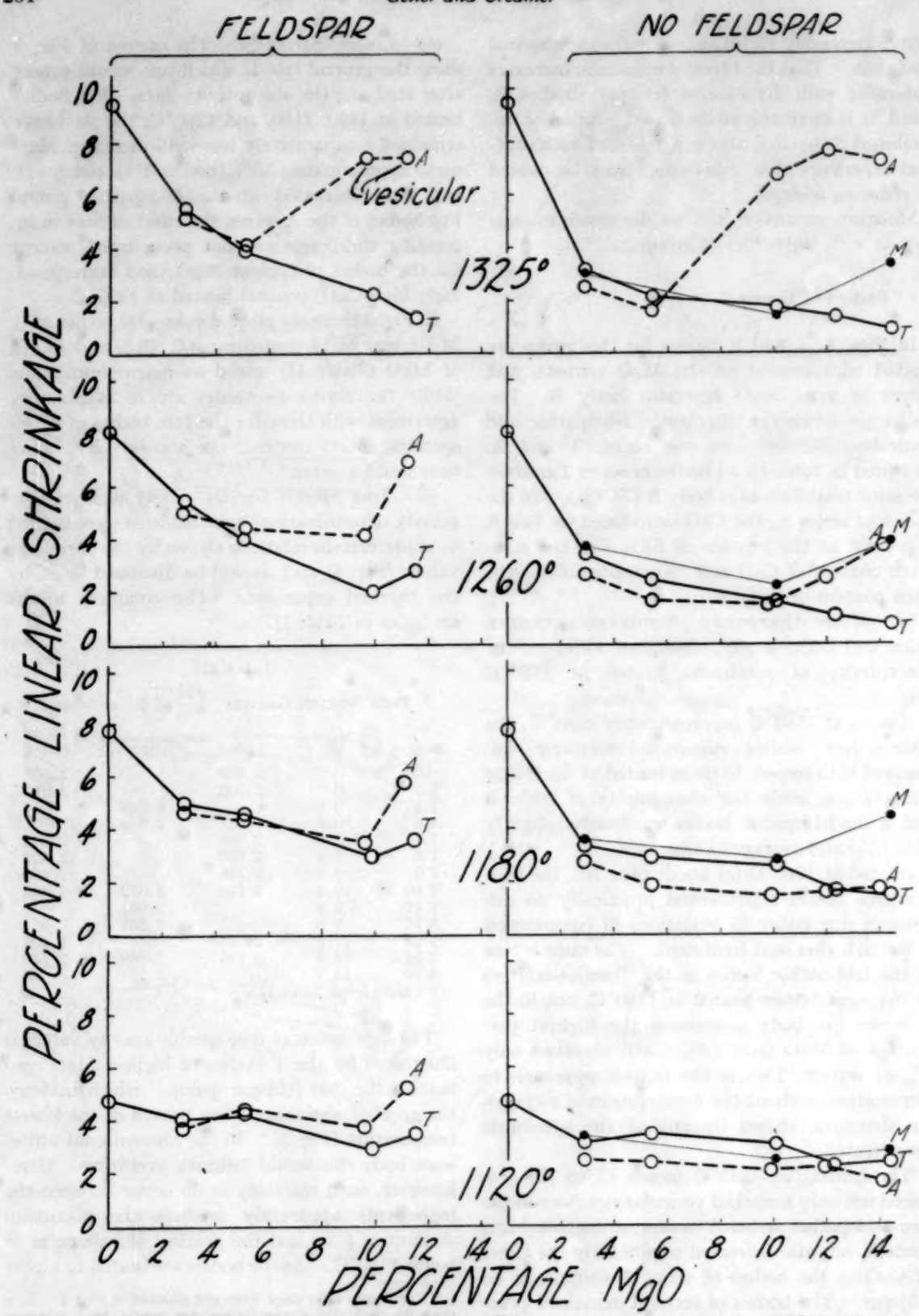

FIG. 3.—Total linear shrinkage from mold to heated state. Values are plotted as in Fig. 2 and *M* identifies the curves connecting values for bodies M 6, M 10, and M 14 (Table II.)

temperatures it appears that additional crystalline phases are formed in a matrix of such rigidity as to prevent further shrinkage. This is evidenced also by the previously noted constancy in absorptivity (Fig. 2). Consequently, changes in true specific gravity accompanying the formation of, or change in, crystalline phases at temperatures above 1120°C appear to cause the decrease in shrinkage. This is illustrated by the curves in Fig. 4.

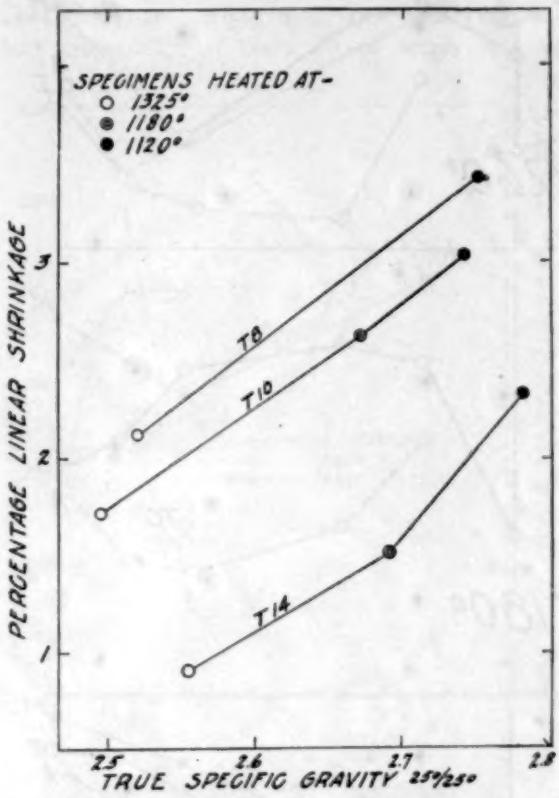

FIG. 4.—Showing the relation between shrinkage and true specific gravity for the three bodies highest in MgO content and containing no feldspar.

(*d*) *X-Ray Patterns.*—The X-ray patterns were obtained by R. H. Ewell of this Bureau, and his report is given as Table IV. Clinoenstatite was not identified in any body. Two unidentified lines in the patterns for body A 14 are possibly due to some compound of lime, since this body contains 3.2% of CaO. The pattern for talc A alone, heated at 1325°C for one hour, shows the lines for clinoenstatite and also the stronger of these two unidentified lines while talc T, containing no lime, does not show this line. (The spacing of the other unidentified line coincides with the spacing for a strong line in the clinoenstatite pattern and therefore would not show.) The results show that cordierite had begun to form in bodies heated at 1180°C.

(*e*) *Linear Thermal Expansion.*—The information is summarized by the curves in Fig. 5. The four outstanding tendencies observed are (1) increase in expansions with increase in MgO content of bodies heated at 1120°C; (2) a lowering of expansion with increased temperature in heat treatment; (3) the lowest expansions were shown by bodies of series A and of intermediate MgO content; and (4) the disproportionate effect of CaO in depressing thermal expansion.

TABLE IV

RESULTS OF X-RAY STUDIES OF BODIES, HEATED AT TWO TEMPERATURES, OBTAINED BY THE POWDER METHOD USING MO-Kα-RADIATION

Body	Cordierite (a)	Cordierite (b)	Quartz (a)	Quartz (b)	Cristobalite (a)	Cristobalite (b)	Tridymite (a)	Tridymite (b)	Mullite (a)	Mullite (b)
T 6		M		M		M		N		W
T 10	W*	S*	M	N	M	M	N	N	N	N
A 10	M*		M		M		N		N	
T 14	N*	S	S	W	M	M	N	N	N	N
A 14	N	M	S	W	M	M	N	W	N	N

* The letters in the table indicate relative intensity of the lines and signify S, strong; M, medium; W, weak; N, none.

(*a*) Bodies heated at 1180°C.
(*b*) Bodies heated at 1325°C.

The first two tendencies noted are in all probability accounted for by the formation of cordierite, which not only undergoes unusually small thermal volume changes[3] but, during its formation, some of the free silica is combined. The bodies of intermediate MgO content undergo the least expansion because they contain MgO, Al_2O_3, and SiO_2 in such proportions as to permit the formation of the highest percentages of cordierite for the series of body compositions investigated. Krause and Jäkel[4] also noted that relative thermal expansion was determined by the cordierite in a series of bodies they investigated.

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[3] R. F. Geller and Herbert Insley, "Thermal Expansion of Silicates of Elements in Group II of the Periodic System," *Bur. Stand. Jour. Research*, **9**, 35 (1932); R. P. 456; *Ceram. Abs.*, **11** [10] 542 (1932).

[4] (*a*) Otto Krause and Ernst Jäkel, "Steatite-Containing Bodies in the Ternary System MgO–Al_2O_3–SiO_2," *Ber. deut. keram. Ges.*, **15** [9] 485–500 (1934); *Ceram. Abs.*, **14** [6] 145 (1935).

(*b*) Otto Krause and Ernst Jäkel, "Thermal Expansions of Ceramic Bodies of the 3-Component System, MgO–Al_2O_3–SiO_2, Containing Steatite," *Sprechsaal*, **67** [34] 509; [35] 525; [36] 543 (1934) *Ceram. Abs.*, **14** [2] 56 (1935).

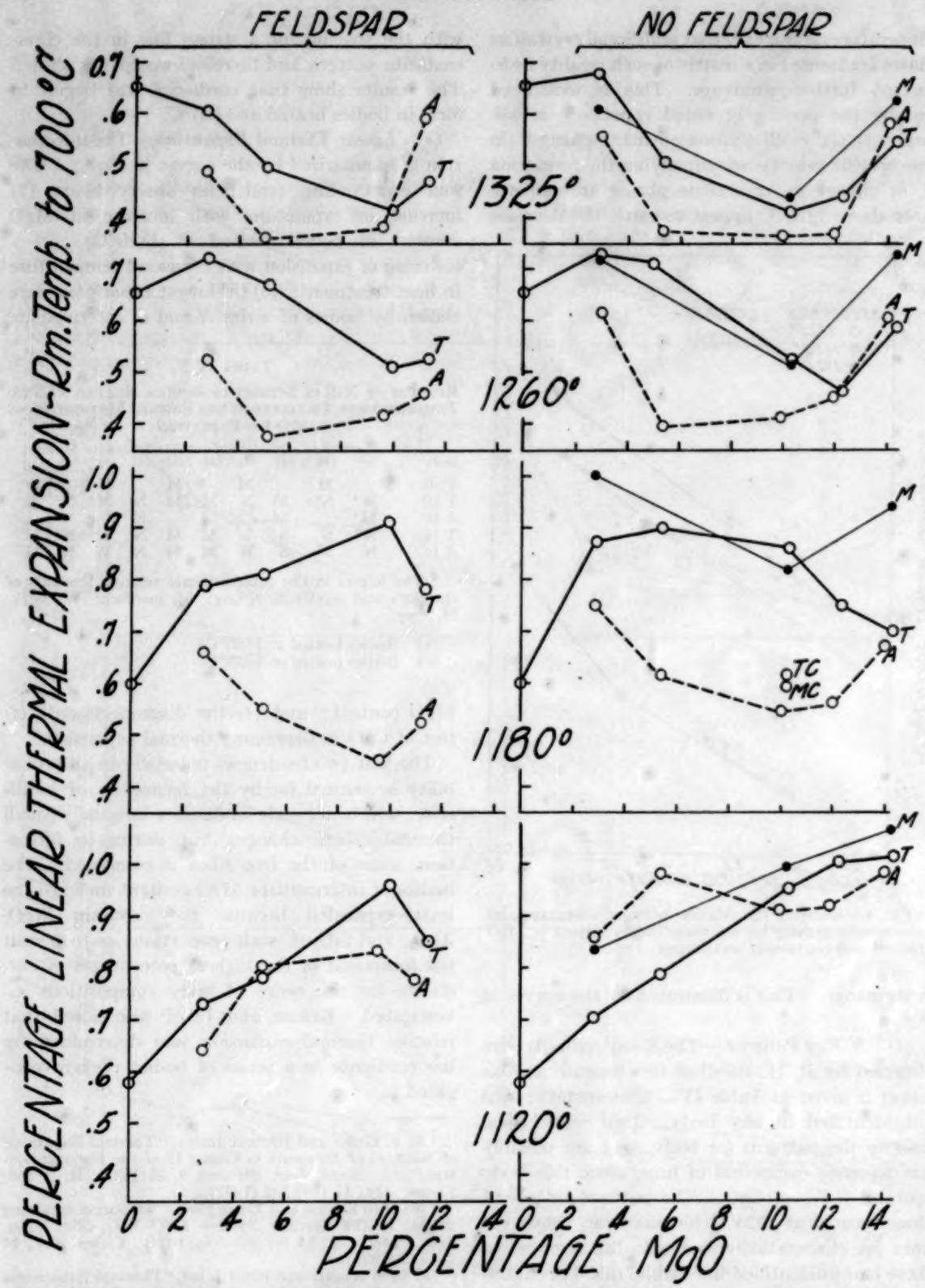

FIG. 5.—Total linear thermal expansion from room temperature to 700°C. As in preceding figures, values for zero MgO represent the reference body B. *T* and *A* indicate curves for bodies made with talc T and talc A, respectively, and *M* designates the curves connecting values for bodies M 6 and M 10, and M 14. Plots identified by the letters *TC* and *MC* are for bodies of the T and M series, respectively, of the same MgO content, which were modified by adding CaO as $Ca(OH)_2$ to make them the equivalent chemically of the corresponding body in the A series (Table II).

That the much lower relative expansions of series A bodies (particularly those heated at 1180°C) can be attributed to the presence of CaO, and not to some other properties or ingredient of talc A, is considered to be demonstrated by the results obtained with bodies TC and MC (1180°C heat, Fig. 5). These bodies, as stated in Table I, were prepared by adding to body 10 of series T and of series M that amount of CaO (as $Ca(OH)_2$) required to make these bodies equivalent chemically to body 10 of series A. As

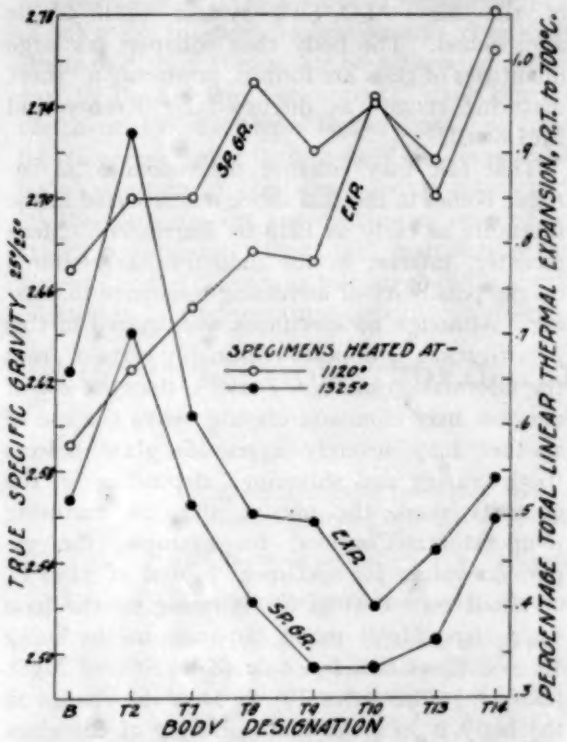

FIG. 6.—Showing the relation between true specific gravity and linear thermal expansion for eight bodies heated at two temperatures.

Fig. 5 shows, the expansions of the modified bodies were lowered sufficiently to approximate that of the series A body.

The graphs in Fig. 6 are presented as typifying the close relation shown by the comparatively large changes in both expansion and true specific gravity.

(3) Moisture Expansion, Color, and Mechanical Strength

The moisture expansion of each body of the T, A, and M series was determined, but only of those specimens heated at 1180 and 1260°C. The results are given in Table V and indicate (1) that the moisture expansion is reduced by talc, (2) that feldspathic glass, in porous bodies such as these, may nullify the effect of talc,[5] and (3) that the presence of lime is beneficial.

No measurements were made of color or mechanical strength. The following statements are merely the result of observations during the course of the laboratory work:

(1) All specimens heated at 1120°C were practically white but had developed insufficient strength to be of industrial use.

(2) Heating at 1180°C produced fairly strong bodies in both the T and A series, but all specimens in the A series containing 10% or more of MgO were light buff in color.

TABLE V

RELATIVE MOISTURE EXPANSION OF BODIES HEATED AT 1180 AND 1260°C

Body	Heated at 1180°C (%)	Heated at 1260°C (%)	Body	Heated at 1180°C (%)	Heated at 1260°C (%)
B	0.05	0.10	M 6	0.01	0.04
1	.04	.05	M 10	.01	.03
2	.01	.02	M 14	.01	.00
T 3	.01	.04	A 3	.01	.01
T 4	.01	.04	A 4	.02	.02
T 5	.03	.03	A 5	.03	.01
T 6	.00	.02	A 6	.00	.01
T 7	.03	.03	A 7	.00	.01
T 8	.01	.00	A 8	.00	.01
T 9	.02	.03	A 9	.00	.00
T 10	.01	.02	A 10	.00	.02
T 11	.00	.03	A 11	.00	.00
T 12	.00	.01	A 12	.00	.00
T 13	.00	.01	A 13	.00	.00
T 14	.00	.00	A 14	.00	.01

(3) The tendency to a buff color was intensified by heating at 1260°C. The color was of a deeper shade and present in those bodies of both series containing more than 5% of MgO. The strength, apparently, was at least equal to that of commercial earthenware.

(4) The highest heat treatment (1325°C) produced vesicular structure in a few bodies (as previously noted); the others of the T and A series appeared measurably stronger than specimens heated at the lower temperatures. The specimens made with the lime-bearing talc (series A) were, if anything, slightly lighter in color compared with those heated at 1260°C, while bodies T 10 to T 14, inclusive, varied from deep buff to light chocolate.

[5] The effect of feldspar in whiteware bodies on resistance to moisture expansion has been investigated. See R. F. Geller and A. S. Creamer, "Moisture Expansion of Ceramic Whiteware," *Bur. Stand. Jour. Research*, **9**, 291 (1932); R. P. 472; *Ceram. Abs.*, **11** [12] 622 (1932).

(5) All specimens of the "M bodies" were white but too weak, mechanically, for practical use.

VI. Discussion

The formation of a rigid matrix predominantly crystalline in character, in contrast to the glassy matrix of relatively low viscosity present in the usual ceramic body, has inhibited the crystalline growth of the various phases. Consequently, the crystals formed are present as complex heterogeneous masses, and changes in phase composition, therefore, were not followed by means of the petrographic microscope. A combination of density values, thermal-expansion curves, and X-ray patterns permits the following general deductions regarding the bodies investigated after they had been heated at the temperatures indicated:

(*a*) 1120°C, composed essentially of anhydrous clay and talc, quartz, and feldspar glass, if feldspar was used.

(*b*) 1180°C, both cristobalite and cordierite formed, augmented materially by CaO and also, to a lesser degree, by the alkalis from the feldspar.

(*c*) 1260°C, this higher temperature produced little change in the bodies containing both feldspar and lime-bearing talc, compared with the bodies heated at 1180°C, but promoted considerable additional growth of cordierite in the other bodies. The formation of a new phase of high thermal expansion is indicated for the mixtures of highest MgO content.

(*d*) 1325°C, the mixtures of series T, and of intermediate MgO content, show continued formation of cordierite and also the further solution of quartz or its transformation to cristobalite, cordierite and cristobalite making up probably two-thirds of the body. In the lime-containing bodies of series A, reactions resulting in the formation of cordierite and cristobalite have evidently neared completion at 1260°C, and the only noteworthy change produced by this heat treatment is the higher expansion and density in the bodies of highest MgO content. Calculations based on the MgO–Al_2O_3–SiO_2 phase relations point to clinoenstatite, which would account for both increased expansion[6] and specific gravity, but, unfortunately, the X-ray patterns do not support the calculations. Consequently, the available information does not explain what becomes of the MgO in excess of that present as cordierite.

Superficially, the absorptivity and shrinkage values indicate pure talc to be almost entirely inert as a flux. Strength, color, specific gravity, and thermal-expansion values, however, show that heating produces changes resulting in bodies having the properties necessary for commercial application. The rigid matrix, composed largely of heterogeneous crystals, has retarded the drawing together of the particles in the body structure, thereby maintaining high absorptivity and low shrinkage, until the lowest eutectic temperature of the MgO–Al_2O_3–SiO_2 system (1345°C) is approached. The body then collapses, as large quantities of glass are formed, producing a "short maturing range" as discussed by Kraner and McDowell.[7]

That talc may enhance the resistance of ceramic bodies to thermal shock was reported in the literature as early as 1913 by Barringer.[8] More recently, interest in the industry has centered on the possibility of increasing resistance to crazing. Although no specimens were glazed in this investigation, it appears reasonably certain, from the information in Figs. 1 and 5, that the use of one talc may eliminate crazing, while the use of another may severely aggravate glaze defects (both crazing and shivering), depending on the quantity used, the purity, and the maturing temperature. Consider, for example, the expansion values for specimens heated at 1180°C, or about cone 5 (Fig. 5). Crazing on the base body (zero MgO) might be overcome by using 10 to 30% of lime-free talc (3 to 10% of MgO, feldspar group, series T); in fact, the change in the body is so great that shivering of the glaze might result. On the other hand, the use of from 15 to 30% of the lime-bearing talc (5 to 10% of MgO, series A) would increase the crazing.

VII. Summary and Conclusions

An investigation was conducted to determine some of the more important effects of MgO, introduced as a lime-free or as a lime-bearing talc, in whiteware of the wall-tile type. The maximum percentage of talc in the bodies was 43, the minimum 2.5. Each series of specimens was heated at 1120, 1180, 1260, and 1325°C (or approximately to cones 1, 5, 10, and 13).

[6] See footnote 4.

[7] H. M. Kraner and S. J. McDowell, "Talc as the Principal Body Ingredient in Vitrified Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **8** [10] 626–35 (1925).

[8] Discussion of paper by C. W. Parmelee and C. H. Baldwin, *Trans. Amer. Ceram. Soc.*, **15**, 545 (1913).

The values obtained show that (*a*) a variation in MgO content from 3 to 14% did not significantly alter the water absorptivity of the heated bodies, this property being influenced much more, relatively, by the alkalis in the feldspar in combination with the CaO; (*b*) the shrinkage, also, was influenced significantly by the CaO in the lime-bearing talc and the alkalis in the feldspar. In general, total linear shrinkage was decreased by the talc; for example, the expansion of specimens heated at 1260°C was decreased from a maximum of 8% for a body containing no talc to a minimum of 0.7% for a body containing 43% of talc; (*c*) moisture expansion was practically eliminated, but this must be accounted for in part by the low feldspar content; (*d*) in general, the thermal expansions of bodies containing lime-free talc were higher than those of the comparable bodies containing the lime-bearing talc; and, (*e*) the data support the conclusion reached by other investigators that the manufacture of vitreous bodies containing talc involves the greatest care in kiln temperature control.

The conclusions based on the bodies investigated and heated at 1180, 1260, and 1325°C are as follows:

(1) In semivitreous bodies, talc may be expected to increase porosity slightly and materially decrease shrinkage when 40% or less is used.

(2) The effect of talc, in quantities of 40% or less, on resistance to crazing due to poor "glaze fit" will depend on the amount used, the temperature, and the content of lime. Small variations in any one of these factors are sufficient to change the thermal expansion through a wide range.

(3) Glazed porous bodies containing as little as 10% of talc (either lime-bearing or lime-free) may be expected to show excellent resistance to "moisture crazing," providing the feldspar content also is low.

Acknowledgment

This investigation was suggested by the Industrial Advisory Committee on Whiteware to the National Bureau of Standards, under the chairmanship of F. P. Hall. Acknowledgment is due also E. N. Bunting for assistance in the laboratory.

X-RAY DIFFRACTION STUDY OF THE STRUCTURE OF SODA-SILICA GLASS*

By B. E. Warren and A. D. Loring

Abstract

X-ray diffraction patterns of soda-silica glass have been made for seven different compositions varying from 0 to 46% Na_2O. For small soda content, the patterns show a single strong peak at $\frac{\sin\theta}{\lambda} = 0.12$; with increasing soda content this peak diminishes in intensity, while at the same time a new peak at $\frac{\sin\theta}{\lambda} = 0.18$ gradually becomes the more pronounced. There is no abrupt change in the patterns. A random network picture of the glass is developed, and upon this basis X-ray intensity curves can be calculated in good agreement with the experimental curves. Each silicon is tetrahedrally surrounded by four oxygens. Part of the oxygens are shared between two silicons; the others are bonded to only one silicon. The double-bonded oxygens build up a continuous silicon-oxygen framework. The sodium atoms are located at random in the various holes in this framework. There is no evidence for the existence of compounds in the range of composition studied.

I. Introduction

The application of X-ray diffraction analysis to a series of simple glasses has been described in previous papers.[1] Vitreous SiO_2 was the first glass to be analyzed and, for this material, it was found possible to interpret completely and quantitatively the X-ray diffraction pattern, thereby determining definitely the atomic arrangement in this typical example of a simple glass. In vitreous SiO_2, it was found that each silicon is tetrahedrally surrounded by four oxygens at a distance of 1.60Å, and that each oxygen is bonded between two silicons, thus building up a continuous three-dimensional silicon-oxygen network. About each atom the number of neighbors is the same as in the crystalline forms of SiO_2, but

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Glass Division). Received March 6, 1935.

[1] (*a*) B. E. Warren, "X-Ray Diffraction of Vitreous Silica," *Z. Krist.*, **86**, 349 (1933).
(*b*) B. E. Warren, "Diffraction of X-Rays in Glass," *Phys. Rev.*, **45** [10] 657–61 (1934).
(*c*) B. E. Warren, "X-Ray Determination of Structure of Glass," *Jour. Amer. Ceram. Soc.*, **17** [8] 249–54 (1934).
(*d*) B. E. Warren and C. F. Hill, "The Structure of Vitreous BeF_2," *Z. Krist.*, **89**, 481 (1934).

although the number of nearest neighbors and their distances are perfectly definite in glassy silica, the orientation of any tetrahedral group with respect to its neighbors is partially random and hence it is a random network which is formed. It does not repeat itself at regular intervals and the material is accordingly noncrystalline. It is this feature which distinguishes the glassy from the crystalline state.

Vitreous SiO_2, GeO_2, and BeF_2 were all found to have the same tetrahedral arrangement in the glassy state. In each case the cation is tetrahedrally surrounded by four anions, and each anion is bonded between two cations. For each of these three simple glasses, the intensity of X-ray scattering could be calculated by the same method developed for the case of SiO_2. The three sets of comparison curves are reproduced in Fig. 1. The experimentally determined intensity of scattering in each case is compared with the theoretical curve calculated on the basis of the tetrahedral arrangement discussed above. In view of the necessary approximations involved in the calculations, the agreement for all three glasses is quite satisfactory and is a convincing verification of the proposed tetrahedral random network in these simple glasses.

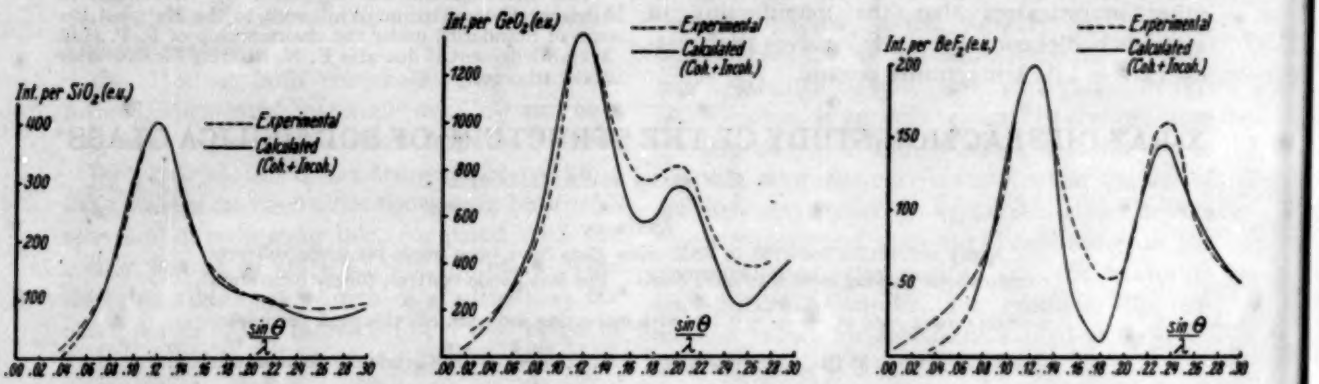

FIG. 1.—Comparison of calculated and experimental X-ray scattering curves for three simple glasses: (*a*) vitreous SiO_2, (*b*) vitreous GeO_2, (*c*) vitreous BeF_2.

The X-ray diffraction study of soda-silica glass reported here represents the first attempt to apply the same methods to a binary glass. The soda-silica series appeared particularly promising for this study, due to the fact that the end member, SiO_2, has been thoroughly analyzed. By studying samples with gradually increasing soda content, we have the advantage of starting out from a known structure. With the introduction of soda, the problem of interpretation of the patterns becomes much more complicated. More approximations are necessary, and the calculations become rather long and tedious. At the time this work was started, the only method of attack consisted of trying various reasonable arrangements of the atoms, calculating the expected intensity curve for each of these arrangements, and then comparing with the experimental curve. Various arrangements and alterations must be tried, and the one giving the best general agreement between calculated and observed intensity curves must be taken as representing the best approximation to a true picture of the atomic arrangement in the glass.

II. Experimental Method

The experimental method of preparing the X-ray diffraction patterns has been described before.[1c] X-rays from a copper target Müller tube are monochromated by reflecting the Kα-line from a rock-salt crystal. The beam passes through the sample, which is in the form of a thin slab situated at the center of the cylindrical camera. During the exposure the camera is evacuated to eliminate air-scattering. Diffraction patterns were made of seven samples* with soda content varying from 0 to 46%.

In each case, the sample was ground down to a thin slab about 0.007 inch thick. At 15 milliamperes and 30 kilovolts, exposures of 30 hours were necessary. The seven patterns are shown in Fig. 2, arranged in order of increasing soda con-

* The various samples used were prepared by G. W. Morey of the Geophysical Laboratory to whom the authors wish to express their thanks.

tent. The striking feature in the series is the perfectly continuous fashion in which the diffraction patterns change with composition. Starting with SiO_2, there is a single strong peak at $\frac{\sin\theta}{\lambda} = 0.12$; with increasing soda content this peak diminishes in intensity while at the same time a new peak at $\frac{\sin\theta}{\lambda} = 0.18$ gradually becomes the more pronounced. There is no evidence for any abrupt change in structure in this range of composition.

TABLE I
COMPOSITION OF SAMPLES

	Na_2O weight (%)	Na_2O molecular (%)
1	0.00	0.00
2	14.84	14.44
3	20.70	20.18
4	26.87	26.25
5	33.90	33.19
6	38.87	38.12
7	46.04	45.25

III. Interpretation of the Diffraction Patterns

The method which has been developed for calculating the diffraction pattern of glass has been described in previous papers.[1b,c,d] The intensity of X-ray scattering is given as a function of the angle by the expression

$$I = \sum_m \sum_n f_m f_n \frac{\sin s r_{mn}}{s r_{mn}} \qquad s = \frac{4\pi \sin\theta}{\lambda} \qquad (1)$$

Where f_n = X-ray scattering factor for atom n
r_{mn} = distance from atom m to atom n
2θ = angle of scattering

It appears from equation (1) that the intensity depends only upon the distances from each atom to all the other atoms and that, if these distances are known, the intensity can be immediately written down as a function of the angle-of-scattering.

The first step is to develop a reasonable picture of the atomic arrangement in a soda-silica glass, the choice being guided to a large extent by the known structures of various crystalline silicates.[2] In the glasses so far studied, it has been found that the interatomic distances and the number of immediate neighbors about each atom are roughly the same as in the corresponding crystalline materials. Hence a detailed knowledge of the crystalline structure of a series of materials of somewhat similar chemical composition is the most valuable clue to the atomic arrangement in the glass.

Representing the chemical composition as $(Na_2O)_x(SiO_2)_{1-x}$, where x is the fractional part of Na_2O (molecular), the relative numbers of the three atoms present will then be

$$\begin{array}{ll} Na = 2x & \frac{O}{Si} = \frac{2-x}{1-x} \geq 2. \\ Si = 1-x & \\ O = 2-x & \end{array}$$

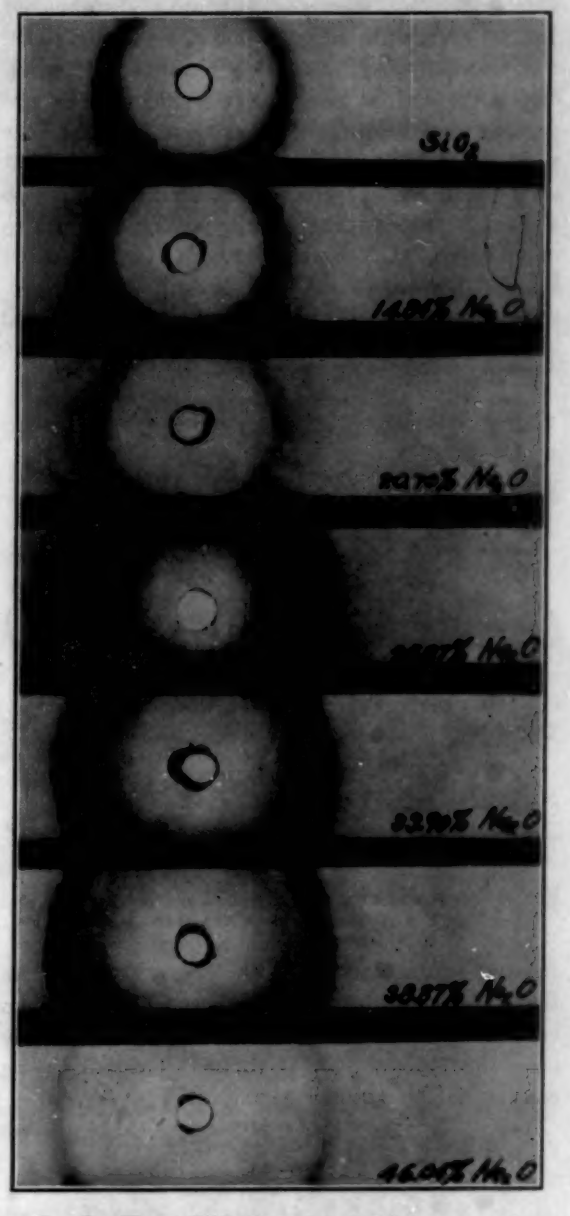

FIG. 2.—X-ray diffraction patterns of seven samples of soda-silica glass. To appreciate the perfectly continuous change in the patterns, allowance must be made for the fact that 20.70 and 46.04 are somewhat underexposed and 26.87 badly overexposed.

[2] W. L. Bragg, "The Structure of Silicates," *Z. Krist.*, 74, 237 (1930).

The number of oxygens, in general, will be greater than twice the number of silicons. From experience with silicate crystals, it can be assumed with certainty that each silicon will be tetrahedrally surrounded by four oxygens at a distance of 1.60Å. When the number of oxygens is just twice the number of silicons, this requires that each oxygen be shared between two silicons. In the present case, with the number of oxygens greater than twice the number of silicons, it is not necessary for all the oxygens to be shared between two silicons, and accordingly there will be two classes of oxygens, O_2 (shared between two silicons) and O_1 (bonded to only one silicon).

If α be the fractional part of oxygens bonded

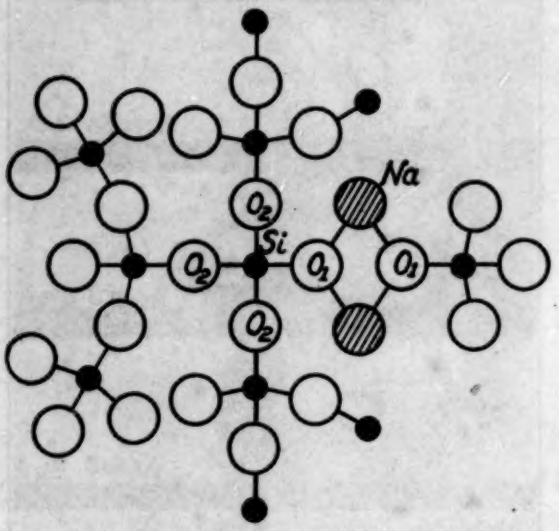

FIG. 3.—Schematic representation of the neighbors about a silicon and a sodium atom.

to only one silicon, then $O_1 = \alpha O$. Since there is one Si–O bond from each atom O_1, two from each atom O_2, and four from each silicon, by equating the number of bonds terminating on oxygen to the number terminating on silicon,

$$1O_1 + 2O_2 = 4Si$$
$$\alpha O + 2(1 - \alpha)O = 4Si$$
$$2 - \alpha = 4\frac{Si}{O} = 4\frac{(1 - x)}{2 - x} \qquad \alpha = \frac{2x}{2 - x}$$
$$\frac{O_1}{Na} = \frac{\alpha O}{Na} = \left(\frac{2x}{2 - x}\right)\frac{(2 - x)}{2x} = 1$$

The number of single-bonded oxygens is equal to the number of sodiums.

Figure 3 represents schematically the arrangement of atoms about any one silicon. The number of neighbors and their distances are then tabulated. First there will be 1 Si at distance zero, since in the summation of equation (1) the atom itself is always included. Next come 4 oxygens at a distance 1.60Å. Part of these 4 oxygens join on to another silicon. To each oxygen O_1 there is a single Si bond, and to each O_2 there are two bonds. The total number of Si–O bonds is therefore $\alpha O + 2(1-\alpha)O = (2-\alpha)O$, and the fraction of bonds leading to oxygens O_2 is

$$\frac{2(1 - \alpha)O}{(2 - \alpha)O} = \frac{(2 - 3x)}{2(1 - x)}.$$

Of the 4 oxygens surrounding the initial silicon, $4\frac{(2-3x)}{2(1-x)}$ join on to another silicon. The next set of neighbors will therefore be $\frac{4-6x}{1-x}$Si at distance 3.20Å. Each of these silicons is tetrahedrally surrounded by 4 oxygens, one of which has already been counted. The next group of neighbors will therefore comprise $3\frac{(4-6x)}{(1-x)}$ oxygens at distance 4.00Å. Of these, a number $\left(\frac{4-6x}{1-x}-1\right)\left(\frac{4-6x}{1-x}\right)$ lead on to another silicon. There will therefore be $\frac{(3-5x)(4-6x)}{(1-x)^2}$ silicons at distance 5.20Å. Each of these silicons will be surrounded by 4 oxygens, one of which has already been counted.

So far, the number of neighbors and their distances are quite definite, regardless of the orientation of the tetrahedral groups. Beyond this, however, the distances depend on the orientation of the groups and therefore become indefinite. From here on, the atomic arrangement can be approximated by a continuous distribution of scattering matter. In the study of the simple glasses, it was possible to make a fairly satisfactory approximation for this continuous distribution, but for a binary glass it becomes too arbitrary to be worth while at this time. Since the continuous distribution affects the diffraction pattern only at small angles, it has seemed better to omit it altogether and then to consider only that part of the intensity curve at large enough angle so that the omission has but little effect. For the outermost silicon and oxygen neighbors, it is a considerable simplification to introduce the same approximation of spherical SiO_2 groups as used in the simple glasses.[1b,c] In addition to the silicon and oxygen neighbors listed above, there will

also be a certain number of Na atoms which will be discussed later.

The neighbors about any sodium atom are the next to be considered. Although most of the neighbors of any silicon atom could be derived by a straightforward algebraic calculation, this is not possible for the neighbors of sodium. In tetrahedral silicon-oxygen framework structures, sodiums will therefore try to arrange themselves in the various framework holes in such a way as to contact as many single-bonded oxygens as possible. From calculations above, it was found that the number of single-bonded oxygens was equal to the number of sodiums. Hence the number of single-bonded oxygens, O_1, contacting any sodium must be equal to the number of so-

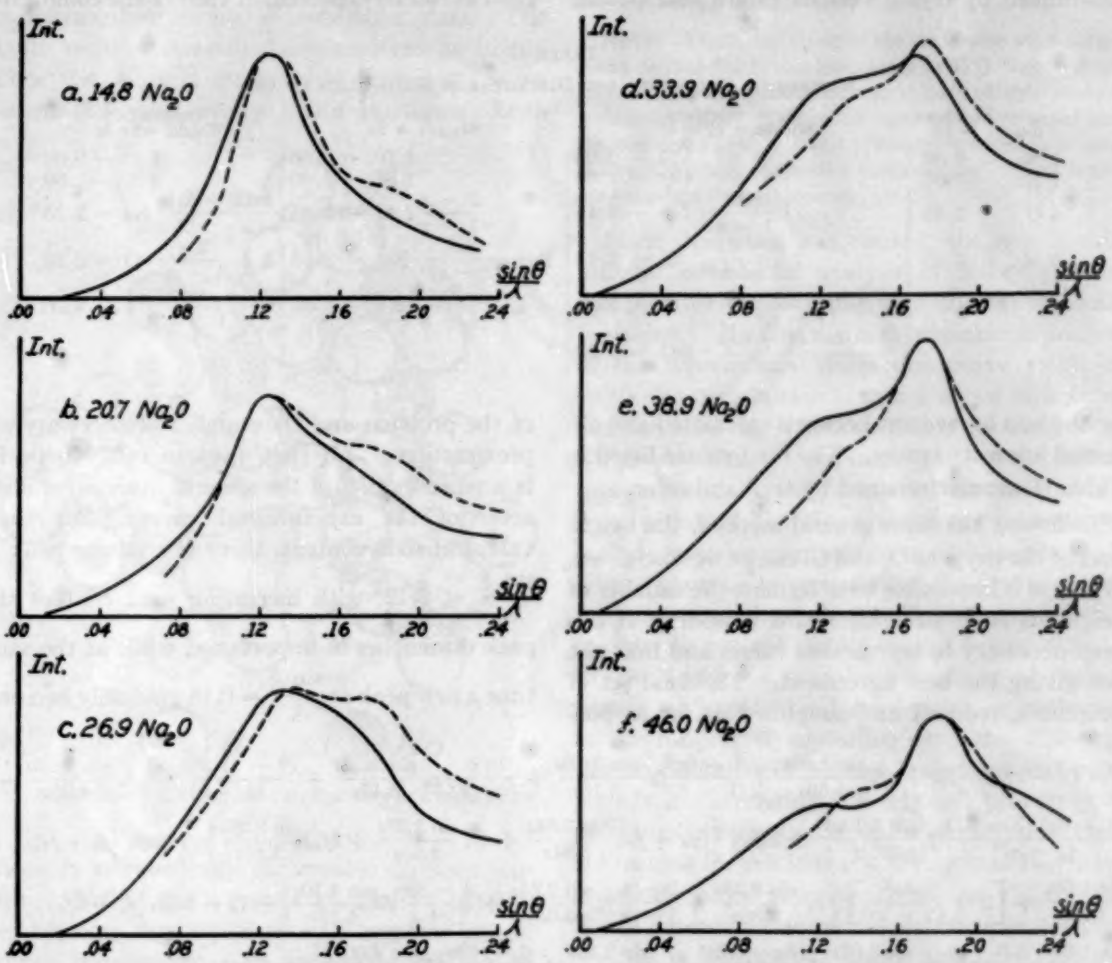

FIG. 4.—Comparison of calculated and observed intensity curves for samples of soda-silica glass. The full-line curves are experimentally observed; the dotted curves are calculated from equation 2.

there are fairly large empty holes between groups of oxygens. In various silicates of this sort, such as the feldspars, these holes are occupied by the large monovalent and divalent alkali atoms. Guided by known structures of this type, it is assumed that the sodium atoms will be arranged at random in these various holes in the silicon-oxygen framework. Since the single-bonded oxygens, O_1, have a residual negative charge, they will attract the positively charged Na atoms. The diums about any oxygen O_1. The number will vary with soda content of the sample, but for low soda values two neighbors is the largest number that can satisfy these requirements in any simple and reasonable way.

Therefore, the somewhat arbitrary assumption has been made that O_1 oxygens will generally occur in pairs sharing 2 sodium neighbors as indicated in Fig. 3. From the known oxygen and sodium radii the distances to nearest oxygens and

silicons can be readily calculated. The neighbors of any one sodium atom will then comprise 1 Na at distance zero, 1 Na at distance 3.80Å, 2 oxygens at 2.35Å, and 2 silicons at 3.45Å. In addition, there will be other oxygen and silicon neighbors, due to the position of the sodium atom in a framework hole, completely surrounded. The number of these additional neighbors can only be determined by trying various values and looking for the best agreement between calculated and observed intensity curves. The final values listed in Table II were determined by trial and error.

In Fig. 4 the intensity curves calculated from equation (2) are compared with the corresponding experimental intensity curves.

The calculated curves are given only for values of $\frac{\sin\theta}{\lambda}$ greater than 0.08, since the omission of the continuous distribution becomes serious for values less than 0.08. The general agreement is fully as good as can be expected, in view of the complexity of the problem and the number of necessary approximations. All that one can really hope for is a reproduction of the general qualitative character of the experimental curves. For small values of soda content, there is a strong peak at $\frac{\sin\theta}{\lambda} = 0.12$; with increasing soda content this peak diminishes in importance, while at the same time a new peak at $\frac{\sin\theta}{\lambda} = 0.18$ gradually becomes the more predominant. This general trend is well reproduced in the calculated curves, and the agreement can therefore be considered as quite satisfactory.

TABLE II

NUMBER OF NEIGHBORS AND DISTANCES IN SODA-SILICA GLASS

Sodium neighbors Weight = $2x$		Silicon neighbors Weight = $(1-x)$		Oxygen O_1 Weight = $2x$		Oxygen O_2 Weight = $2-3x$	
1 Na	0.00	1 Si	− 0.00	1 O	− 0.00	1 O	− 0.00
1 Na	3.85	4 O	− 1.60	1 Si	− 1.60	2 Si	− 1.60
4 O	* 2.35	$\frac{10x}{1-x}$	Na − 3.45	$\frac{2-x}{1-x}$	O − 2.65	$\frac{4x(2-3x)}{(2-x)2}$	Na − 2.35
5 Si	3.45	$\frac{4-6x}{1-x}$	Si − 3.10	$2+\frac{8x^2}{(2-x)^2}$	Na − 2.35	$3+\frac{2x}{1-x}$	O − 2.62
		$\frac{(3-x)(2-3x)}{(1-x)^2}$	O − 4.00	$4-\frac{2x}{1-x}$	SiO_2 − 4.00	$6-\frac{4x}{1-x}$	SiO_2 − 4.00
		$\frac{(3-5x)(4-6x)}{(1-x)^2}$	SiO_2 − 5.20				

$$I = (1-x)f_{Si}\left\{f_{Si} + 4f_0\frac{\sin 1.60s}{1.60s} + \frac{4-6x}{1-x}f_{Si}\frac{\sin 3.10s}{3.10s} + \frac{10x}{1-x}f_{Na}\frac{\sin 3.45s}{3.45s} + \frac{(3-x)(2-x)}{(1-x)^2}f_0\frac{\sin 4.05s}{4.05s} + \right.$$
$$\left.\frac{(4-6x)(3-5x)}{(1-x)^2}f\frac{\sin 5.20s}{5.20s}\right\} + 2xf_{Na}\left\{f_{Na} + f_{Na}\frac{\sin 3.84s}{3.84s} + 4f_0\frac{\sin 2.35s}{2.35s} + 5f_{Si}\frac{\sin 3.45s}{3.45s}\right\} + 2xf_0\left\{f_0 + f_{Si}\right. \quad (2)$$
$$\left.\frac{\sin 1.60s}{1.60s} + \left[2+\frac{8x^2}{(2-x)^2}\right]f_{Na}\frac{\sin 2.35s}{2.35s} + \frac{2-x}{1-x}f_0\frac{\sin 2.65s}{2.65s} + \frac{4-6x}{1-x}f\frac{\sin 4.10s}{4.10s}\right\} + (2-3x)f_0\left\{f_0 + 2f_{Si}\right.$$
$$\left.\frac{\sin 1.60s}{1.60s} + \frac{3-x}{1-x}f_0\frac{\sin 2.62s}{2.62s} + \frac{8x-12x^2}{(2-x)^2}f_{Na}\frac{\sin 2.35s}{2.35s} + \frac{6-10x}{1-x}f\frac{\sin 4.00s}{4.00s}\right\} + \text{Cont.}$$

sible, is given in Table II. These values were the ones finally selected as giving the best general agreement.

Each of the distributions about the four different types of atoms is weighted by the relative number of atoms of that type present. Substituting the values of Table II into equation (1), an expression for the intensity of scattering is obtained as a function of the angle and the chemical composition, equation (2).

A number of variations in the distribution of neighbors was tried during the calculations. The distribution finally selected was the one giving the best general agreement between the calculated and observed intensity curves. Any appreciable departure from the distribution

finally selected resulted in a definitely less satisfactory agreement between the two sets of curves. The final distribution must therefore represent the distribution of neighbors in a soda-silica glass as closely as X-ray diffraction analysis can give it.

IV. Discussion of Results

Figure 5 represents schematically the disordered arrangement of atoms in soda-silica glass. The figure must necessarily be considered as highly schematic, since it attempts to represent in two dimensions what really exists in three. Each

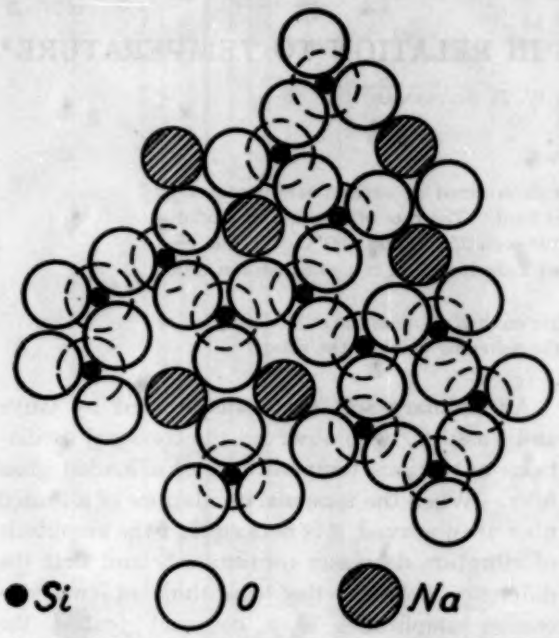

FIG. 5.—Schematic arrangement of atoms in a soda-silica glass.

silicon is tetrahedrally surrounded by four oxygens. Part of the oxygens are shared between two silicons, thus building up a random silicon-oxygen framework. The sodium atoms are located in various holes in this framework, presumably arranging themselves in such a way as to contact as many single-bonded oxygens as possible. Although Fig. 5 places the sodiums in pairs, this should not be considered as esssential or as having been deduced from the X-ray analysis, since the intensity curve is changed but little by having the sodiums occur singly and distributed at random in the various framework holes.

The picture of a soda-silica glass which has been deduced here from X-ray diffraction study is in good agreement with the physical nature of the glass. The atomic arrangement does not repeat itself at regular intervals, and the material is accordingly noncrystalline and isotropic. The atomic distribution which has been postulated in this discussion and found to give a satisfactory agreement between the calculated and observed X-ray diffraction patterns is exactly the type of arrangement which Zachariasen[3] had predicted for an alkali-silica glass.

NOTE: The X-ray study of the lead oxide-silica glasses, being carried out in this laboratory by G. J. Bair, will provide an excellent check on the results of this study of soda-silica glass. The results reported in this paper must be considered as only a first preliminary attempt to apply X-ray diffraction study to a binary glass. There is need for considerable further work.

Since this work was started, the new Fourier integral method of analysis of X-ray patterns has been used successfully on a number of similar problems.[4] By this method, a harmonic analysis of the experimental diffraction curve yields directly the distribution of atoms about each atom, and hence as much information is obtained about the atomic arrangement in the glass as the diffraction pattern inherently contains, the information being obtained directly, without the necessity of making any assumptions or approximations. It is now planned to repeat all of the previous glass studies, using the new Fourier integral method in order to put the results upon a firmer basis.

The X-ray results give no evidence of the existence of hypothetical compounds or molecules in the range of composition studied. Although the introduction of various molecules and compounds in correlating the physical properties of glass is extremely useful and advantageous, there are reasons for thinking it unlikely that they have a definite physical existence in the glass. The X-ray determination of the structure of complex crystalline silicates has shown definitely that the various hypothetical molecules which had been previously assumed really have no existence in the structure. The same work has also shown that the primary factor in determining the stability of a silicate is the tetrahedral surrounding of each silicon by four oxygens. Any molecular grouping which did not provide each silicon with

[3] W. H. Zachariasen, "The Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54**, 3841 (1932).

[4] (*a*) B. E. Warren and N. S. Gingrich, "Fourier Integral Analysis of X-Ray Powder Patterns," *Phys. Rev.*, **46**, 368 (1934).

(*b*) B. E. Warren, "X-Ray Diffraction Study of Carbon Black," *Jour. Chem. Phys.*, **2**, 551 (1934).

its four oxygen neighbors would be too unstable to exist in the glass. Since the number of oxygens is never as great as four times the number of silicons, part of the oxygens must necessarily be shared between two tetrahedral groups. In this sharing of oxygens there is the further rule derived from silicate crystals that the groups share only corners but never edges or faces. As an example, the metasilicate molecule, $Na_2O \cdot SiO_2$, could not exist as a definite discrete unit in the glass. In the discrete units, each silicon would have only three oxygen neighbors and this would be a highly unstable configuration. To achieve four oxygens about each silicon, two of the oxygens in each group would have to be shared between two groups. The original $Na_2O \cdot SiO_2$ molecule would then be part of some larger complex (chains or closed rings) and would have ceased to exist as a discrete entity.

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MODULUS OF ELASTICITY OF GLASS IN RELATION TO TEMPERATURE*

BY A. E. BADGER AND W. B. SILVERMAN

ABSTRACT

The modulus of elasticity of a glass was determined at various temperatures by measuring the elongation of a glass fiber under load. The rate of decrease of modulus with temperature showed an abrupt change between 250°C and 300°C. It was considered that this phenomenon was connected with the increased rate of expansion which occurs in glasses near these temperatures.

A description is given of an interferometric method of measuring the deflection of compressed specimens at temperatures up to the softening point of the glass.

I. Introduction

(1) Some Previous Investigations

The early work of Winkelmann[1] on the elasticity of glass at various temperatures has been followed in more recent years by other similar investigations[2] dealing chiefly with fused quartz glass. From the latter studies, it appears that anomalies exist in the variation in elasticity of fused quartz glass[3] with temperature, although there may be some doubt concerning these observations.[4]

An ordinary soft glass was studied by Guye and Vassileff,[5] who observed the torsional oscillations at various temperatures of a loaded glass fiber. When the torsional oscillations of a loaded fiber are observed, it is noticed that the amplitude of vibration decreases continuously and that the difference between the logarithms of two successive amplitudes is a constant (called the logarithmic decrement) which is a function of the elastic properties of the glass. Guye and Vassileff found abnormal effects at about 250°C in the ordinary glasses which they tested.

(2) Present Investigation

In the following method, the modulus of elasticity of a glass fiber was measured in direct tension at various temperatures extending to about 450°C. The results apply to the immediate deformations which took place in the glass as a result of the load and not to any slow creep which might occur with longer times of observation.

The chemical composition[6] of the glass was

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Glass Division). Received March 5, 1935.

Published with the permission of M. L. Enger, Director of the Engineering Experiment Station, University of Illinois. The experiments were performed in the Department of Ceramic Engineering, under the direction of C. W. Parmelee, Head of the Department.

[1] A. Winkelmann, "Über die Elasticitätscoefficienten verschieden zusammengesetzter Gläser in ihrer Abhängigkeit von der Temperatur," *Ann. Physik. Chem.*, **61**, 105 (1897).

[2] See Glastechnische Tabellen by W. Eitel, M. Pirani, and K. Scheel, p. 179. Julius Springer, Berlin, 1932.

[3] C. H. Rees, J. P. Andrews, and L. S. Shave, "The Variation of Young's Modulus at High Temperature," *Proc. Phys. Soc.* [London], **36**, 405 (1923); see also references cited by A. Winkelmann and O. Schott, *Ann. Physik. Chem.* (N. F.), **51**, 697 (1894).

[4] H. D. H. Drane, "Elastic Constants of Fused Quartz. Change of Young's Modulus with Temperature," *Proc. Roy Soc.* [London], **A122**, 274 (1929).

[5] C. E. Guye and S. Vassileff, "Frottement Interieur des Verres en Fonction de la Temperature," *Arch. sci. phys. nat.*, **4** [37] 214 (1914).

[6] Chemical analysis by Bailey and Sharp Co., Hamburg, N. Y.

68.10 SiO_2, 3.38 R_2O_3, 4.09 MgO, 5.84 CaO, and 18.59 alkalis.

II. Description of Method

(1) Form of Test Specimen

The modulus of elasticity of glass in tension was determined by loading a glass fiber and measuring the elongation by means of micrometer microscopes. The arrangement of the apparatus is shown in Fig. 1.

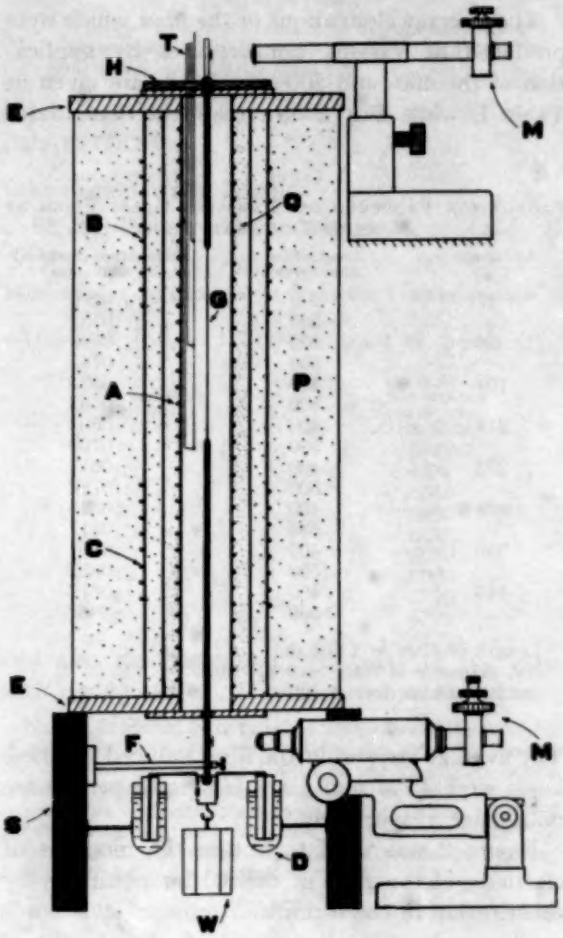

FIG. 1.

The glass fiber, *G*, was made by drawing out a 15-centimeter section from a molten glass rod 5 millimeters in diameter, attempts being made to produce a fiber of uniform diameter and with sharply defined junctions with the original rod. The ends of the glass rod were enlarged by fusion in order to fit them into the upper support, *H*, and the loading device, *W*.

About forty measurements of the fiber diameter were made with a micrometer microscope and the average diameter of the rod was taken as the square root of the mean of the squares of the measurements. The average diameter of the fiber as computed in this manner was 0.427 millimeter, the minimum diameter at any point being 0.305 millimeter.

The length of the sample was found by measurements with a cathetometer to be 143.2 millimeters.

(2) Suspension of Glass Fiber

The glass sample, *G*, consisting of two sections of the original rod with the fiber as mid-section, was placed vertically in a tubular electric furnace. The upper support for the rod was a brass plate, *H*, which was protected from direct furnace radiation by a small plate of Transite board.

The ball-shaped lower end of the glass rod supported a loading hook where weights, *W*, could be easily attached or removed. Small vanes on the loading device dipped into oil reservoirs, *D*, which damped accidental vibrations of the glass sample. A plate of Transite, which encircled the lower part of the glass rod without touching it, served to close the bottom of the furnace tube.

(3) Description of Furnace

The furnace[7] consisted of a Pt wire-wound tube, *A*, 18 inches long and $1^1/_2$ inches in bore, which was insulated with powdered magnesia, *Q*, and Sil-O-Cel, *P*. Transite pieces, *E*, were used as end pieces for the sheet-iron shell of the furnace, which was supported on blocks, *S*.

The furnace was equipped with auxiliary heating coils, *B* and *C*, of Chromel wire, which were used to bring the glass fiber to as uniform a temperature as possible.

(4) Temperature Measurements

The temperature of the glass fiber, *G*, was measured near its middle and two ends by means of three thermocouples, *T*. The power input to the heating coils of the furnace was adjusted so that a maximum difference of 10°C existed among the three thermocouples at any furnace temperature.

[7] Designed and built by W. R. Morgan.

(5) Measurement of Elongation of Fiber

Two micrometer microscopes, *M*,*M*, were focussed on fiducial marks[8] near the upper and lower parts of the glass rod. Weights, *W*, were then added to the rod and the elongation was computed from the difference between the readings of the two microscopes. The change in the indication of the upper microscope was always small and was caused by the settling of the system on application of the load to the fiber.

An adjusting screw mounted on a support, *F*, was used to aid in maintaining the lower end of the rod in focus in the microscope when the load, *W*, was changed.

The measured elongation of the glass sample was made up of the elongations of the fiber and of the original rod to which the fiber was attached. From the relative area and lengths of the fiber

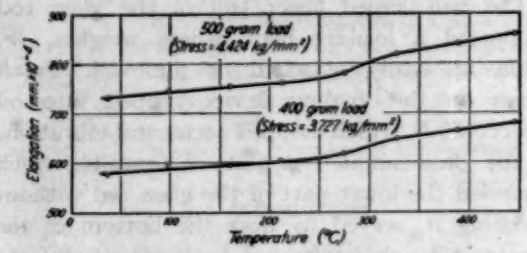

FIG. 2.—Elongation at various temperatures of glass fiber under load.

and original rod, it was computed that 97.9% of the elongation took place in the fiber. A correction for this error was applied to the measurements of elasticity given below.

The dead load on the glass fiber, due to the weight of the loading device and lower section of the glass rod, was 125 grams. Readings of the two micrometer microscopes were taken under these dead-load conditions, and an additional weight of 400 grams was then placed on the loading hook. The readings of the micrometer microscopes were again obtained and the elongation of the glass sample under an added load of 400 grams was determined from the difference between the initial and the final readings. A similar set of determinations was made, using a 500-gram additional weight. As a rule, ten measurements were made at various glass temperatures with each load.

[8] The fine marks on mica plates were suggested for this purpose by D. G. Moore.

(6) Annealing of Glass

The glass fiber was annealed before making the elasticity determinations by raising its temperature to 550°C and allowing it to cool slowly in position in the furnace.

III. Results of Tests

(1) Computation of Modulus of Elasticity[9]

The average elongations of the fiber which were produced at various temperatures by application of the 400- and 500-gram loads are given in Table I, while Fig. 2 is a graph of these data.

TABLE I

ELONGATION PRODUCED BY STRESSING GLASS FIBER AT VARIOUS TEMPERATURES

Av. temp. (°C)	Load added to fiber (grams)	Elongation produced by load (mm.)
37	400	0.0576
	500	.0731
98	400	.0593
	500	.0745
101	400	.0594
	500	.0753
212	400	.0603
	500	.0760
275	400	.0617
	500	.0780
328	400	.0645
	500	.0817
389	400	.0661
	500	.0837
446	400	.0677
	500	.0857

Length of fiber = 143.2 mm.
Av. diameter of fiber = 0.427 mm.
Initial load on fiber = 125 g.

The average stresses in the fiber induced by these loads were 3.727 and 4.424 kilograms per square millimeter, respectively.

Figure 2 was used to obtain the modulus of elasticity of the glass at desired temperatures by substitution in the formula

$$E = \frac{L\,(S_1 - S_2)}{A(L_1 - L_2)}$$

Where E = the modulus
L = length of glass fiber
A = area of cross-section of fiber
S_1 and S_2 = loads added (500 and 400 grams, respectively)
L_1 and L_2 = elongations produced by loads, S_1 and S_2.

[9] This modulus of elasticity refers to the mean value as obtained from the difference in the elongations produced by two stresses and might be called "chord modulus of elasticity." A similar term is used on page 147 of Einführung in die Mechanik fester elastischer Körper und das zugehörige Versuchswesen, by R. Girtler. Julius Springer, Vienna, 1931.

Table II gives the results of such computations while Fig. 3 shows them in graphic form. The values of E in Table II have been corrected for

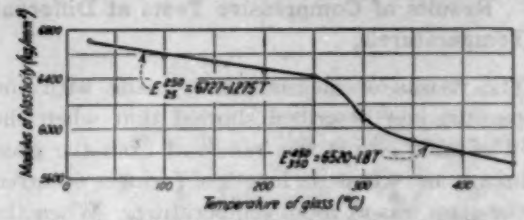

FIG. 3.—Modulus of elasticity of glass at various temperatures (initial stress = 3.727 kg./mm.²; final stress = 4.424 kg./mm.²

the elongation of the glass rod and so apply only to the fiber.

(2) Summarized Results

Figure 3 shows the values given in Table II

TABLE II

MODULUS OF ELASTICITY AT VARIOUS TEMPERATURES OF GLASS FIBER

(Between stresses of 3.727 and 4.424 kg. per mm.²)

Av. temperature of glass fiber (°C)	Modulus of elasticity of glass between stresses noted, E (kg./mm.²)
25	6710
100	6580
150	6540
200	6460
250	6420
300	6070
350	5900
400	5790
450	5710

and also the decrease in elasticity of the glass with temperature. The increased rate of change

NOTE: It should be noted that the values of the modulus of elasticity were not corrected for the small increase in the cross-section and the length of the glass fiber which occurred when its temperature was raised. This correction was neglected since it amounted to less than 1% at the maximum temperature. If the correction had been applied, the values of modulus would be reduced slightly at the higher temperatures.

of modulus between 250°C and 300°C is analogous to the change in logarithmic decrement which Guye and Vassileff[10] observed near these temperatures.

The empirical equations,

$$E_{25}^{250} = 6727 - 1.275T \text{ and } E_{350}^{450} = 6520 - 1.8T,$$

where E = modulus of elasticity of glass in kg./mm.² between stresses of 3.727 and 4.424 kg./mm.²

T = temperature of the glass (°C),

may be used to show the variation of modulus with temperature within the temperature intervals noted.

[10] See footnote 5.

(3) Precision of Method

The largest single error which affected the absolute values of modulus of elasticity was due to the variation in cross-section of the glass fiber.

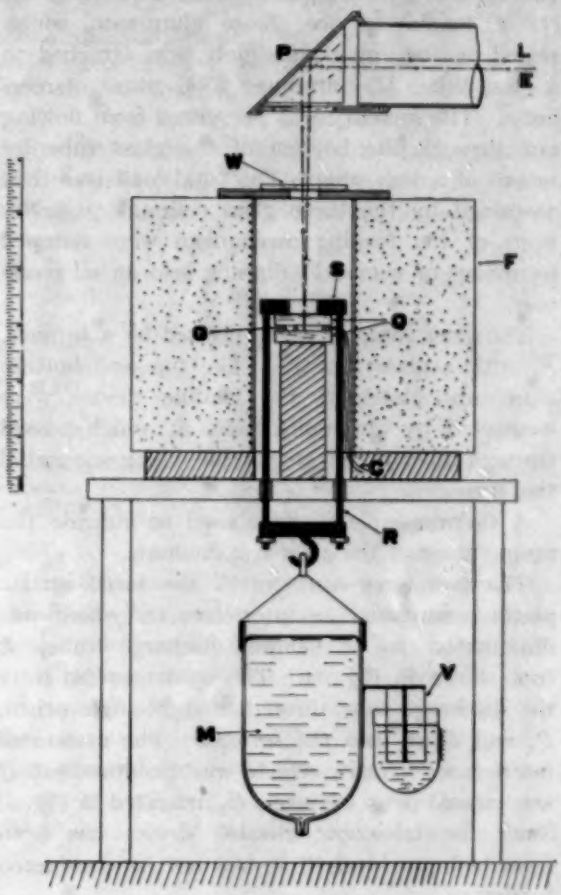

FIG. 4.

Although the absolute accuracy of the method was only about ±5%, it was found that the value of modulus of elasticity obtained at room temperature was only 2% greater than that obtained by another more accurate method.[11] The relative precision of the determinations is about ±0.5%.

IV. Modulus of Elasticity under Compression

(1) Description of Method

An attempt was made to study the modulus of elasticity of glass under compression at various temperatures by means of the apparatus shown in Fig. 4.

[11] By D. G. Moore and W. B. Silverman.

The glass sample, *G*, was in the form of three small columns (0.0974 inch long and 0.048 inch diameter) which were ground to nearly exactly equal lengths. These columns were placed between plane-polished plates of fused quartz glass, *Q*. A loading device, *S*, of aluminum, which rested on the upper glass plate, was attached to a glass tube, *M*, containing 2500 grams of mercury. The mercury was prevented from flowing out through the bottom of the glass tube by means of a wax plug. The total load was thus sustained by the three glass columns. Oscillations of the loading mechanism were damped by means of vanes, *V*, dipping into an oil reservoir.

The glass samples were enclosed by a furnace, *F*, with a glass top, *W*. The top and bottom aluminum plates of the loading device were connected by aluminum rods, *R*, which passed through holes in the steel table which supported the furnace.

A thermocouple, *C*, was used to indicate the temperature of the glass test columns.

The two inner surfaces of the fused quartz plates constituted an interferometer which was illuminated by a helium discharge tube, *L* (not shown in Fig. 4). The light traveled from the discharge tube through a right-angle prism, *P*, and down into the furnace. The system of interference fringes which was produced at *Q* was viewed in an eyepiece, *E*, indicated in Fig. 4. Since the telescopic viewing device has been described previously,[12] it will not be considered further.

This apparatus was so sensitive that ordinary methods of loading would disturb the interference fringes. This necessitated the design of a loading device which could be used without touching the apparatus after adjustment. In this method the mercury was poured into the glass receptacle, *M*, and the system of fringes was observed when oscillation had ceased. A Bunsen burner flame, which was applied to the bottom of the mercury holder, caused the wax seal to melt. The mercury then flowed out into a reservoir and the load (except for the suspending mechanism) was thus removed from the glass specimens. The passage of interference fringes was observed during this period, each fringe being equivalent to a change in length of the glass specimens of one-half wave-length of helium light.

[12] L. D. Fetterolf and C. W. Parmelee, "Effect of Soda, Barium, and Zinc on the Elasticity and Thermal Expansion Coefficients of Glass," *Jour. Amer. Ceram. Soc.*, **12** [3] 193–216 (1929).

(2) Results of Compressive Tests at Different Temperatures

The results of measurements made with the apparatus just described showed that when the load of 2500 grams was removed from the glass columns, an increase in length of 7 fringes occurred if the glass was at room temperature. When the temperature was raised to about 415°C, the extension amounted to $7\frac{1}{2}$ fringes. The modulus of elasticity, therefore, decreases by about one part in fifteen when the glass temperature changes from room temperature to 415°C.

The low precision of this experiment precluded any hope of finding variations in modulus of elasticity at small differences of temperature. In fact the extension of about 7 fringes (0.0002 cm.) was actually the effect of a 2500-gram load on small glass columns which had finely ground ends. If these ends had been polished, the extension would have been much smaller. Therefore, only the change in modulus as affected by temperature and not absolute values could be computed from such data.

V. Conclusion

The quite pronounced change in the modulus of elasticity which was observed at 250 to 300°C in the tension tests on glass is probably allied with the distinct increase in thermal expansion which generally occurs near these temperatures in glasses.[13]

The increased thermal expansion causes a greater separation of the molecules which constitute the glass with a resultant weakening of the intermolecular forces. The glass, therefore, becomes easier to distort under load and hence a lower value of modulus of elasticity is obtained.

Since the thermal endurance of glass is favored by a low modulus of elasticity, the sharp decrease in modulus at 250 to 300°C tends to counteract the effect of the increase in thermal expansion which occurs in this temperature interval.

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[13] E. Seddon and W. E. S. Turner, "The Behavior of Glass When Slowly Heated, with Special Reference to the Thermal Expansion," *Jour. Soc. Glass Tech.*, **17**, 324 (1933).

NOTE ON THE EFFECT OF ZIRCONIA ON THE CHEMICAL DURABILITY OF SOME BOROSILICATE GLASSES*

By William Horak and Donald E. Sharp

Abstract

Four meltings were made on a small scale of a borosilicate glass in which ZrO_2 was progressively substituted for Al_2O_3. Determinations of chemical durability showed that the substitution increased the resistance of the glasses to weathering.

I. Introduction

In a study of soda-zirconia-silica glasses, Dimbleby and Turner[1] found that substitution of zirconia for silica brought about a decided improvement in chemical durability when the corrosive agent was water, hydrochloric acid, or sodium carbonate solution. These results led Voinot and Appen[2] to attempt to improve the durability of dense barium crown optical glasses by substituting zirconia for part of the silica. They were unable, however, to find any improvement in resistance to weak acids when zirconia was employed in amounts up to 5%.

In view of the strong influence of zirconia on the mechanical properties of enamels, as reported by Kinzie and Commons,[3] it was thought desirable to determine the effect on chemical durability of replacing alumina by zirconia in some heat-resisting glasses of a borosilicate type.

II. Preparation of Glasses

Four glasses were melted on a small scale (about one-half pound), the batches being calculated to yield the compositions listed in Table I. Appropriate allowances were made for the prospective losses by volatilization of Na_2O, B_2O_3, and ZnO. The glasses were not analyzed, but as all four were identical in batch composition except for the replacement of the alumina by zirconia, it was assumed that they would be practically identical in final composition except for the differences in alumina and zirconia. All four glasses were melted in one furnace at the same time and thus were subjected to the same conditions of time and temperature.

Table I

Glass*	A (%)	B (%)	C (%)	D (%)
SiO_2	70	70	70	70
Na_2O	10	10	10	10
B_2O_3	12	12	12	12
ZnO	4	4	4	4
Al_2O_3	4	3	2	0
ZrO_2	0	1	2	4

* Compositions of glasses melted for durability tests as calculated from the batches and corrected for losses by volatilization.

It will be noted that glass A contained no zirconia and that in the other glasses zirconia replaced alumina progressively until complete substitution was obtained in glass D. There seemed to be a little difference in melting rate between the various glasses, but glass D was noticeably stiffer when poured from the crucible. Each of the glasses was poured out in the form of a plate which was annealed before measurements were made.

III. Method of Measuring Chemical Durability

The plates of glass were crushed and screened to pass through a 140-mesh sieve and to remain on a 200-mesh sieve. A 5-gram sample was carefully weighed out and boiled in distilled water for three hours in a seasoned Pyrex-brand flask under a reflux condenser. The filtered solution was titrated against $N/20$ sulfuric acid, using methyl red as an indicator. The amount of attack was expressed in percentage of Na_2O extracted as calculated from the titration.

IV. Results of Tests

The measurements show a well-defined improvement in durability as zirconia is substituted for alumina. This is the more remarkable when it is remembered that alumina itself is extremely

* The results reported herein were obtained in the course of some investigations on effects of zirconia in glass sponsored by the Titanium Alloy Mfg. Co., Niagara Falls, N. Y.

Received May 10, 1935.

[1] V. Dimbleby and W. E. S. Turner, "Relationship between Chemical Composition and Resistance of Glasses to Action of Chemical Reagents," *Jour. Soc. Glass Tech.*, **10**, 324–55 (1926).

[2] W. G. Voinot and A. A. Appen, *Jour. Opt. Mech. Ind.*, U.S.S.R. No. 12, p. 8 (1932).

[3] C. J. Kinzie and C. H. Commons, "Effect of Zirconium Oxide on Glasses, Glazes, and Enamels," *Jour. Amer. Ceram. Soc.*, **17** [10] 283–87 (1934).

powerful in adding to the corrosion resistance of a glass and that borosilicate glasses of the type considered are inherently of good chemical durability. The actual results of averaged check measurements were as follows:

ZrO_2 in glass (%)	Na_2O extracted (%)
0	0.009
1	.004
2	.003
4	.002

It is worth noting that small amounts of zirconia have a decided influence and that as the amount is increased the rate of improvement seems to be proportionally smaller. As an approach is made nearer and nearer to "zero" solubility, however, it is natural that the percentage effect on the alkali extracted should appear to be less. The picture may be more readily grasped by plotting the percentage of zirconia against the reciprocal of the percentage of alkali extracted. This reciprocal might be termed the "resistance to corrosion" and would become infinite, of course, when the amount of alkali extracted became zero. Figure 1 illustrates the effect on the "resistance" of the replacement of alumina by zirconia and indicates that the increase in resistance is a reasonably progressive and regular one.

There is the possibility, of course, that in addition to the alkali some boric oxide is also extracted from the glass in the determination of durability by the method described herein and might have some influence on the results. Such tests as have been made did not indicate that this was a disturbing factor, but measurements are being made by other methods to confirm this.

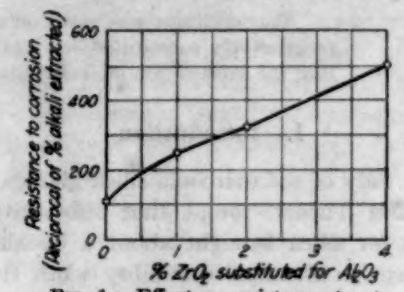

FIG. 1.—Effect on resistance to attack of substituting ZrO_2 for Al_2O_3 in glasses studied.

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HAMBURG, NEW YORK

NOTE ON THE INFLUENCE OF ZIRCONIA ON THE ELASTICITY OF SOME SODA-LIME GLASSES*

BY WILLIAM HORAK AND DONALD E. SHARP

ABSTRACT

Measurements of the moduli of elasticity and of rigidity were made on four soda-lime glasses containing ZrO_2. Both moduli are lowered by the substitution of ZrO_2 for CaO.

I. Introduction

Zirconia has found an extended use in enamels, largely to promote opacity. Recently Kinzie and Commons[1] studied the effect of zirconia on the physical properties of enamels, including its effect on the modulus of elasticity. They found that the use of zirconia in enamels lowered the modulus of elasticity while favorably affecting other properties as well. It seemed that zirconia might affect soda-lime glasses in a manner similar to its action in enamels. Accordingly, a series of four meltings of such glasses was made in this laboratory to study the effect of zirconia on elasticity when substituted for part of the lime in a typical soda-lime-silica glass.

II. Preparation of Samples and Method of Testing

The compositions of the glasses studied, as calculated from the batch after allowances were made for volatilization of soda and for pot attack, were as follows:

* The results reported herein were obtained in the course of some investigations on the effects of zirconia in glass sponsored by the Titanium Alloy Mfg. Co., Niagara Falls, N. Y.

Received May 10, 1935.

[1] C. J. Kinzie and C. H. Commons, "Effect of Zirconium Oxide on Glasses, Glazes, and Enamels," *Jour. Amer. Ceram. Soc.*, 17 [10] 283–87 (1934).

	A (%)	B (%)	C (%)	D (%)
SiO_2	74	74	74	74
Na_2O	17	17	17	17
CaO	9	8	7	5
ZrO_2	0	1	2	4

These glasses, after being melted, were drawn into rods about 0.30 centimeter in diameter and annealed. It was noticed while drawing the cane that glass D appeared to be more viscous and to set more quickly than did glass A. The annealed rods were fairly uniform in diameter.

The modulus of elasticity was determined by supporting the rods on knife edges and applying a load through another knife edge midway between the end supports. The deflection caused by a definite load was measured by a micrometer screw with an electrical contact to indicate when

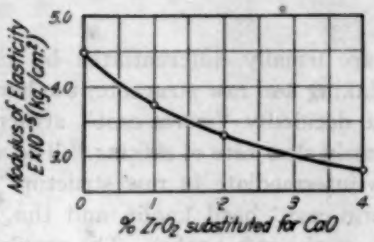

FIG. 1.

the screw touched the saddle of the load-bearing knife edge.

III. Modulus of Elasticity

The results of these measurements are shown in Table I and indicate that the substitution of ZrO_2 for CaO decreases the modulus of elasticity of a soda-lime-silica type glass quite rapidly. This is shown graphically also in Fig. 1.

TABLE I

ZrO_2 (%)	$E \times 10^{-6}$ (kg./cm.²)
0	4.48
1	3.74
2	3.31
4	2.81

IV. Modulus of Rigidity

Since the torsion pendulum was used by Kinzie and Commons, a set of determinations on the glasses was also made by this method. Threads, measuring about one millimeter in diameter and three feet long, were drawn from each of the glasses. A disk, six inches in diameter and of known moment of inertia, was sealed at one end of the thread while the other end was sealed to a fixed support, and the period of vibration was determined for each glass. The results are given in Table II and in Fig. 2, and it is to be noted that

TABLE II

ZrO_2 (%)	$R \times 10^{-6}$ (kg./cm.²)
0	2.71
1	2.56
2	2.48
4	2.43

the modulus of rigidity also decreases as ZrO_2 is substituted for CaO.

V. Interpretation

The modulus of elasticity, as given here, is a measurement in flexure, while the modulus of

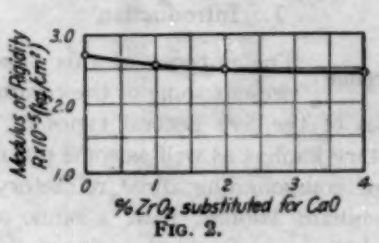

FIG. 2.

rigidity is a measurement under shearing stresses. The results obtained in these experiments agree with those of Kinzie and Commons[1] in that the effect of zirconia is to decrease these moduli. It could not be expected that the actual figures would be similar because the types of glasses in the experiments were so different in composition from those of Kinzie and Commons, the latter being made on enamels and the former on typical soda-lime glasses.

In using thin fibers or threads, the surface effects become so prominent that they may actually predominate over the internal effects. Any lowering of the modulus of elasticity will result in a tougher surface which is less likely to be marred and scratched by rough handling.

A lower modulus of elasticity is naturally a desirable property in a glass. It indicates increased resistance to shock, which is one of the most important of the mechanical properties of glass,[2] and it increases the work-absorbing power

[2] James Bailey, "The Problem of Malleable Glass," *Bull. Amer. Ceram. Soc.*, **14** [4] 152 (1935).

of the material, resulting in greater impact strength, greater thermal endurance, and less likelihood of breakage in use.

The use of relatively small amounts of zirconia in soda-lime glasses lowers the modulus of elasticity and, assuming that the tensile strength is not lowered in the same degree, would improve the mechanical properties of the glass.

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TEST DATA ON STIFF-MUD REFRACTORIES MADE FROM GEORGIA SEDIMENTARY KAOLINS UTILIZING VOID CONTROL*

BY W. HARRY VAUGHAN

ABSTRACT

A discussion is given of the pyrophysical characteristics of different types of Georgia sedimentary kaolins suitable for refractories. Working and drying character, shrinkage, absorption, fired crushing strength, spalling resistance, pyrometric cone equivalent, and load-bearing properties at high temperatures are given for some bodies made of semihard and hard sedimentary kaolins.

I. Introduction

(1) Purpose The purpose of this paper is to present some of the ceramic characteristics of the five general types of Georgia sedimentary kaolins as well as some pyrophysical results of compounding three refractory bodies from semihard kaolins, hard kaolins, and materials which occur in the deposits of these kaolins. The most dense-packing practical grog components were used, making 8-mesh the largest particle in these bodies.

II. Properties of Sedimentary Kaolins

There are five types of sedimentary kaolins commonly recognized in Georgia. They are the hard, semihard, soft, flint, and bauxitic kaolins. It is regrettable that much of the technical literature on work with Georgia sedimentary kaolins exhibits neither the source nor type of clay. Stull and Bole[1] were the first writers to outline Georgia kaolin types. It must be understood that these classifications are somewhat arbitrary.

(1) Texture The hard, semihard, soft, and bauxitic kaolins grade into one another as far as visual examination will determine. Of course, there are chemical analyses to indicate the bauxitic type which carries high alumina content. The hard, semihard, and soft kaolins are usually differentiated by means of rate of slaking and raw structure, the hard kaolin having a decidedly "worm-cast" structure and an extremely slow rate of slaking. The semihard kaolin is intermediate in raw structure between the "worm-cast" hard kaolin and the "mealy" structure of the soft kaolin. The semihard kaolin is moderately slow slaking, and the soft kaolin slakes rather rapidly. For this reason, the soft kaolins were the first sedimentary kaolins to be developed in Georgia. The rapid slaking character is concomitant with ease of filter-pressing. The flint kaolin is easily recognized since it is usually yellow to brown in color and exhibits a conchoidal fracture similar to the flint clays of

TABLE I

AVERAGE CHEMICAL ANALYSES OF SEDIMENTARY GEORGIA KAOLINS*

No. of samples	Hard 47	Semihard 14	Soft 54	Flint 6	Bauxitic 17
Al_2O_3	38.83%	38.71%	39.16%	27.35%	42.22%
SiO_2	42.85	43.33	43.11	57.57	38.37
Hydrated SiO_2	0.24	0.17	0.18		
Fe_2O_3	1.68	1.46	1.21	2.05	1.33
TiO_2	1.09	1.20	1.14	2.07	1.23
Na_2O	0.19	0.10	0.12	0.09	0.23
K_2O	tr.	tr.	tr.	0.08	0.06
CaO	tr.	tr.	tr.	tr.	tr.
MgO	0.14	0.03	0.04	tr.	tr.
P_2O_5	tr.	0.10	0.11	tr.	tr.
SO_3	0.11	0.05	0.16	tr.	tr.
Ignition loss	13.15	13.32	13.36	10.78	16.16
P.C.E.	34–35	33–35	33–35	31–33	34–37

* Largely taken from *Geol. Surv. Georgia Bull.*, No. 44, "Sedimentary Kaolins of the Coastal Plain of Georgia," by R. W. Smith.

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February 14, 1934 (Refractories Division). Received February 15, 1934.

[1] R. T. Stull and G. A. Bole, "Beneficiation and Utilization of Georgia Kaolins," *U. S. Bur. Mines Bull.*, No. 252.

Pennsylvania, Maryland, and Kentucky. This kaolin develops no plasticity when ground to 30-mesh. The average chemical analyses and pyrometric cone equivalents of these kaolins are approximately represented in Table I.

(2) Composition The average composition of these clays is given to show that the differences in raw physical and pyro-

TABLE II

AVERAGE PLASTIC PROPERTIES OF SEDIMENTARY GEORGIA KAOLINS DETERMINED WITH SLOP-MOLDED BARS

Property	Type of kaolin				
	Hard	Semihard	Soft	Flint	Bauxitic
Slaking	Very slow (if at all)	Slow	Fairly rapid	No	Slow
Plasticity	Excellent	Good	Fair	No	Poor
H_2O of plasticity (%)	25	28	35	No	29
Shrinkage H_2O	10		12	No	5
Pore H_2O	15		23	No	24
Dry modulus of rupture (lb./sq. in.)	220	60	45	No	25
Linear dry shrinkage (% plastic basis)	6.0	5.2	5.5	No	3.0

physical characteristics can not be explained on the basis of any differences which may be found in the chemical analyses of the first three types of kaolins. Some of the properties of the flint

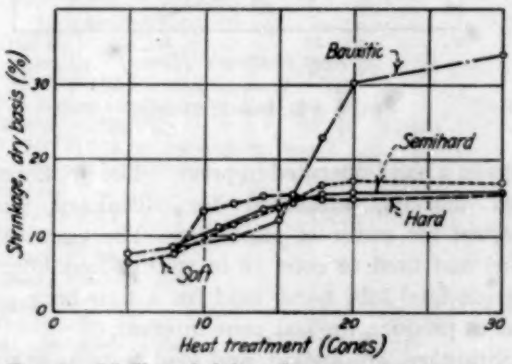

FIG. 1.—Median shrinkage-heat treatment curves for four types of Georgia sedimentary kaolins.

and bauxitic kaolins may be predicted from the chemical analysis.

Briefly, there are a few facts of interest to the producer of refractories which may be noted in the processing characteristics of the various kaolins.

(3) Working Character The flint kaolins do not become plastic under ordinary treatment. The bauxitic kaolins are variable. Some develop plasticity comparable to the soft kaolins, others hardly develop sufficient plasticity to hold them together. In general, they are slightly less plastic than North Carolina primary kaolins. The soft kaolins are fairly plastic, but tend to become short with additions of non-plastics. They are somewhat difficult to work by the stiff-mud process in combination with an equal quantity of grog. The semihard kaolins are more plastic than the soft kaolins, but generally produce friable mixtures with an equal quantity of grog. The hard kaolins are plastic, strong, and satisfactory for stiff-mud processes.

(4) Drying Character With few exceptions, the sedimentary kaolins dry successfully. These exceptional clays are ex-

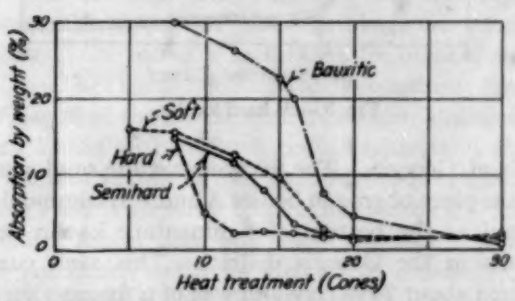

FIG. 2.—Median absorption-heat treatment curves.

tremely weak. Shrinkage is, as usual, about proportional to the plasticity of the clay.

(5) Pyrophysical Properties All of the five types of kaolins have refractory possibilities either as grog, plastic, or as a source of alumina or silica. The following curves are given to show the physical differences between the different types of sedimentary kaolins at high temperatures. Results shown in the curves[1] (Figs. 1 and 2) were obtained on bars formed by the slop-mold process. Comparative results for the native material as mined yielded slightly lower firing shrinkages and lower absorptions at all heat treatments (Figs. 3, 4, and 5). This fact was particularly noticeable in the case of the bauxitic kaolin which did not form a continuous body in the plastic condition. It will be

[1] Some values used in these curves were obtained from the thesis of T. H. Fitzpatrick, "Effect of High Temperature on the Properties of Soft and Bauxitic Kaolins of Georgia," under the direction of A. V. Henry of the Ceramic, Department, Georgia School of Technology (1932).

noted that the flint kaolin has been omitted in the curves. This raw material, as far as is known, has never been systematically investigated.

III. Stiff-Mud Tests

(1) Materials The materials consisted of typical semihard and hard kaolins from the Cretaceous formations in the Fall Line

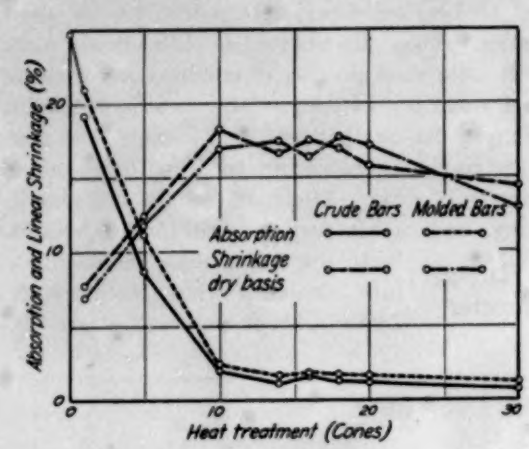

FIG. 3.—A, hard kaolin.

hills of Georgia. The micaceous white sand used in the place of grog in bodies A and F is commonly found at the bottom of sedimentary kaolin deposits in the Georgia district. This sand contained about 24% clay and was of a fineness such

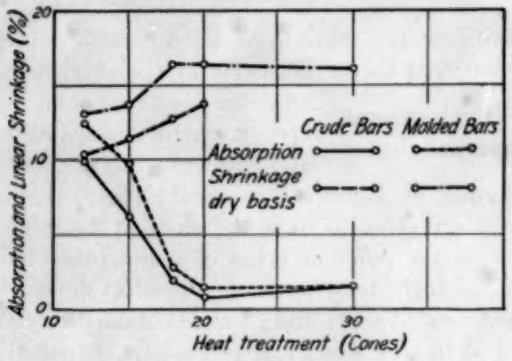

FIG. 4.—F, soft kaolin.

that 93% would pass 40-mesh. The pyrometric cone equivalent of this sand was $29^1/_2$.

The grog used in bodies A and F was obtained by calcining dobies made of the bond clay in A to cone 16, allowing a four-hour period between cones 15 and 16. The grog used in body D, from the same source as the bond, was made into dobies and calcined to cone 16. All grog was crushed in the double rolls and screened with hand screens which approximated the Bureau of Standards openings for equivalent screen numbers.

(2) Procedure The bodies were compounded by weight of plastics and nonplastics. The screenings for the nonplastics were determined by shaking the mixtures until the one which gave a maximum packing of particles from practical screen ranges was obtained. The bond clays were ground to pass 20-mesh.

Two 100-pound batches were placed in the wet pan and run for fifteen minutes while tempering to the proper consistency. The plastic masses were fed to the auger machine and extruded, wire cut, and re-pressed into firebrick

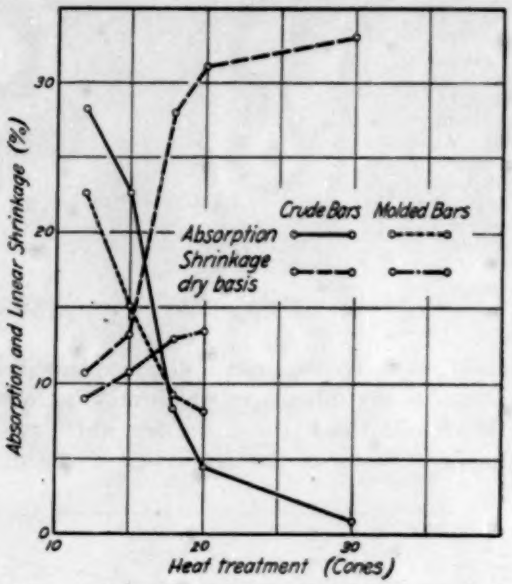

FIG. 5.—D, bauxitic kaolin.

slugs in a hand-operated re-press. The brick were then marked, measured for shrinkage, and weighed for water of plasticity. The ware was dried and fired to cone 16 in twenty-four hours, the gas-fired kiln being held for a four-hour period to produce the last cone interval.

Shrinkage, absorption, and load tests were run on the resulting brick. Since the results of the load tests were not encouraging, the brick were reset and fired to cone 18 in eighteen hours, soaking for a four-hour period to produce the last cone interval.

The brick were again tested for shrinkage, absorption, and load resistance at high temperatures. The twenty-five pounds per square inch

load tests at 2462°F (1350°C) were satisfactory, so the A and F brick were set aside for spalling tests, shrinkage on reheat to 2800°F, and further load tests at 2642°F (1450°C), and, in the case of the F batch, 2732°F (1500°C). By accident, the kiln was finished at 2750°F with a 12-hour soaking under moderate reducing conditions instead of cone 21. Since mixture D withstood this firing condition remarkably well, it was decided to put these brick through the spalling and load tests in lieu of the cone 18 brick.

TABLE III

SURVEY OF PYROPHYSICAL TESTS OF THREE KAOLIN FIREBRICK MIXTURES

Body	A	F	D
Composition in % by weight			
Cone 14, semihard kaolin grog			
8–20 mesh	30.0	30.0	
40-dust	15.0	15.0	
Cone 16 hard kaolin grog			
8–20 mesh			35.0
40-dust			35.0
Micaceous white sand			
Through 40-mesh	20.0	20.0	
Semihard kaolin	35.0		
Hard kaolin		35.0	30.0
Bindex	0.5	0.5	
Extruding behavior	Fairly good	Good	Fairly good
Water of plasticity (%)	16.6	13.4	10.4
Drying shrinkage (%)	2.14	1.55	1.11
Total shrinkage (%)			
Cone 16	6.33	3.82	2.79
Cone 18	6.63	4.32	3.17
2800°F (6-hr. soaking, cone 30)	8.85	5.65	3.43
Absorption (%)			
Cone 16	13.70	13.50	10.50
Cone 18	9.43	11.23	9.43
2800°F (6-hr. soaking, cone 30)	5.05		7.06
2750°F (12-hr. soaking, reducing conditions)	2.17	2.31	5.93
Crushing strength (lb./sq. in.)			
Cone 18 brick	7500	4960	
2750°F (12 hr. soaking, reducing conditions)			9800
Load test (% deformation at 25 lb./sq. in.)			
2462°F (1350°C)			
Cone 16	1.81	1.72	1.44
Cone 18	0.06	0.06	0.09
2750°F (12-hr. soaking, reducing conditions)			0.05
2642°F (1450°C)			
Cone 18	5.31	2.14	
2750°F (12-hr. soaking, reducing conditions)			0.78
2732°F (1500°C)		Fails	
2750°F (12-hr. soaking, reducing conditions)			2.94
Spalling test (loss/dip)			
Cone 18 brick	1.31	1.77	
2750°F (12-hr. soaking, reducing conditions)			1.76
Pyrometric cone equivalent			
Brick	32¾	33	34
Bond kaolin	34	33–34	34
Micaceous white sand	29½	29½	
Weight of a standard-sized brick			
Cone 18	7.63	7.70	
2750°F (12-hr. soaking, reducing conditions)			8.54

Pyrometric cone equivalent tests were made on three sample brick fired to cone 16, the bond kaolins, and the micaceous white sand.

Cold crushing strength tests were made on brick A and F, fired to cone 18, and brick D, fired to 2750°F.

All tests were conducted according to A.S.T.M. specifications.[3]

The weights of standard-sized fire brick were calculated.

IV. Summary

Curves showing firing shrinkage and absorption of the hard, semihard, soft, and bauxitic kaolins gave the following results:

(1) The hard, semihard, and soft kaolins have about the same linear firing shrinkage, but they differ in the heat treatment at which shrinkage apparently ceases. Firing shrinkage is much higher in the bauxitic kaolin than the other types.

(2) The hard kaolin attains constant fired shrinkage at the lowest heat treatment, the semihard kaolin two to three cones higher, and the soft kaolin at four to five cones higher heat treatment than is required for the hard kaolin. The bauxitic kaolin does not reach constant shrinkage conditions until the interval of cones 20 to 30 is reached.

(3) Minimum absorptions are obtained at the same temperatures as maximum shrinkage.

(4) Preliminary results indicate lower absorptions on the calcined crude material than on the plastic molded, at any given heat treatment.

Examination of the data in Table III shows the following results:

(1) Shrinkage and absorption are more nearly ultimate high-temperature values in the cone 18 brick than in the cone 16 brick. Cone 18 firing improves the load-bearing and heat-shrinkage qualities of these bodies.

(2) Brick fired to cone 18 or higher hardly show measurable deformation under load at 1350°C (2462°F).

(3) The results of the water spalling and pyrometric cone equivalent tests were well above the requirements for high duty fireclay fire brick.

(4) Brick D shows very high resistance to load at 1450°C and 1500°C (2642° and 2732°F).

[3] A. S. T. M. Designations C 16–20, C 24–28, and C 38–27T.

(5) Brick, made of dense-packing grog components and utilizing a corresponding reduced amount of bonding material, exhibit a surface free from crow-footing, a uniform internal structure relatively free from laminations, and a high crushing strength.

V. Conclusions

(1) Neither a chemical analysis nor a pyrometric cone equivalent test is sufficient evidence to classify a sedimentary kaolin. The physical structure in the raw condition and a test of working properties are the most reliable criteria.

(2) The common Georgia kaolins of the Coastal Plain (hard, semihard, soft, and bauxitic) fire dense at successively higher temperatures in the order named, although the pyrometric cone equivalent tests show almost identical values.

(3) All refractories made of Georgia sedimentary kaolins designed for heat duty above 2400° F should be fired to cone 16 or higher. Cone 18 or higher firings should be employed where the refractory is to withstand high heat duty, severe spalling and slagging, heavy load, or abrasion.

(4) Grog for refractory skeletons made from Georgia sedimentary kaolins should be ground from calcined lumps rather than dobies.

(5) The application of the void theory[4] to produce dense refractory fire brick results in strong ware at both ordinary and high temperatures, and the reduction of laminations, shrinkage, absorption, and crowfooting.

(6) Exceptionally high-grade clay refractories may be economically manufactured from Georgia sedimentary kaolins. The hard kaolins offer the greatest commercial possibilities since they are plastic, fire dense at the lower heat treatments, and occur in abundance.

Acknowledgment The precise work of A. B. Johnson in the execution of test procedure on the refractory bodies is appreciated.

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Atlanta, Georgia

[4] This theory has been credited to the concrete technologists. It was delineated by A. E. R. Westman and H. W. Hugill, "The Packing of Particles," *Jour. Amer. Ceram. Soc.*, 13 [10] 767–79 (1930).

ERRATA

F. H. Riddle and A. B. Peck, "Effect of Repeated Firing on the Specific Gravity and Microstructure of Some Aluminous Silicate Minerals, July *Journal*, page 194, footnote 5 should read "From Oreana, Pershing County" (not Palmer County).

August *Journal*, Table of Contents, the title of the paper by W. K. Carter, G. H. Duncombe, E. E. Hillyer, and R. M. King should read "Influence of Sodium Aluminate in a Fireclay Sewer-Pipe Body" (not Sodium Carbonate).

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Vol. 14 **September, 1935** **No. 9**

Abrasives

Copper and abrasives. H. L. Wynn. *Amer. Machinist*, **79** [11] 403 (1935).—Powdered glass is particularly suitable as an abrasive with copper, because the particles do not embed in the material and continue to have a grinding effect even after the powder has been wiped off. This is not true of most abrasives, especially the artificial abrasives. Powdered glass gives best results when mixed with ordinary lubricating oil; it can be used for all kinds of lapping. E.J.V.

Polishing wheels. George Muscio. *Metal Cleaning & Finishing*, **7** [6] 303–304 (1935).—Types of wheels employed in metal-polishing operations, methods of setting them up, and their applications are discussed. E.J.V.

Norbide. Anon. *Arch. Rec.*, **76** [6] 28 (1934).—Norbide is a laboratory-produced material, described as the hardest man-made material for commercial use. It may be molded and is second only to diamond dust as an abrasive. A booklet may be obtained from Norton Co., Worcester, Mass., describing its uses. E.B.H.

PATENTS

Abrasives. I. G. Farbenind. A.-G. Fr. 777,162, Feb. 13, 1935; *Chem. Abs.*, **29**, 3799 (1935).—Condensation products obtained from maleic acid (or anhydride) and organic compounds of the formula $R'CHOHXR^2$ where X is $—CH_2CHOH—$, —CHalkylCHOH—, or $—CH_2CH{:}CH—$, R′ is H or an aliphatic hydrocarbon radical, and R^2 is H or an aliphatic ester group (R′ and R^2 may be interchanged) are used as binding agents for abrasives. Examples are given of the use of condensation products from maleic acid and castor oil, 1,3-butyleneglycol and 2-ethylhexanediol-1,3.

Air-brake bushing grinder. A. C. Brignoni (J. B. Craft). U. S. 2,007,847, July 9, 1935 (Aug. 14, 1934).

Centerless grinding machines. Aktiebolaget Malcus Holmquist. Brit. 429,968, June 26, 1935 (July 26, 1933).

Device for setting and protecting diamond-edged tools, etc. Wilhelm Winter. U. S. 2,006,854, July 2, 1935 (Aug. 31, 1932).

Form grinding. S. J. Harley. U. S. 2,007,717, July 9, 1935 (Jan. 13, 1933).

Grinding machine. F. E. Gardner. U. S. 2,007,967, July 16, 1935 (Feb. 8, 1934). Charles Herfurth (Cincinnati Grinders, Inc.). U. S. 2,006,554, July 2, 1935 (May 27, 1932). F. J. Theler (Cincinnati Grinders, Inc.). U. S. 2,006,724, July 2, 1935 (Sept. 25, 1931).

Grinding machinery. F. S. Haas (Cincinnati Grinders, Inc.). U. S. 2,006,570, July 2, 1935 (July 28, 1931).

Grinding and polishing machines. A. F. Kelm. Brit. 429,314, June 13, 1935 (April 25, 1934).

Grinding wheel. A. O. Bush and R. H. Martin (Norton Co.). U. S. 2,006,308, June 25, 1935 (July 13, 1933).—An abrasive article comprises a body of abrasive grains bonded by vitrified ceramic material and an adjacent strengthening body comprising vulcanized hard rubber; the bodies are secured together as an integral unit by a vulcanized rubber bond which fills the pores of the vitrified body and intimately unites with the bond in the rubber-bonded body.

Grinding wheel. P. R. Lundqvist, Brit. 430,687, July 3, 1935 (May 16, 1933). Norton Co., Brit. 429,415, June 13, 1935 (July 3, 1933).

Knife-grinding attachment. Sol Oxenhandler. U. S. 2,006,510, July 2, 1935 (Sept. 7, 1934).

Method and apparatus for making abrasive metal carbides. R. R. Ridgway (Norton Co.). U. S. 2,005,956, June 25, 1935 (Dec. 2, 1931).

Method of making porous articles of ceramic bonded granular material. W. L. Howe (Norton Co.). U. S. 2,007,053, July 2, 1935 (March 18, 1932; March 6, 1935).—The method of making a highly permeable porous article of ceramic bonded material comprises the steps of mixing highly refractory granular material of selected grain size, which upon being heated to the firing temperature of the body is substantially incapable of any permanent volume change, with a vitrifiable ceramic bond containing a low percentage of a refractory clay and a relatively higher

[1] The boldface number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

amount of a low-melting fluxing material which are so constituted and proportioned that the bond will be a highly fluid glass at the firing temperature of Seger cone 13 and will be free from undissolved material and a vesicular structure, the bond constituents being present in an amount such that the grains will lie substantially in contact with one another and will be cemented together into an integral porous body without forming closed pores to any large extent, molding the article and firing it at a temperature not less than Seger cone 13, and causing the bond to flow and settle down as a coating over the grain surfaces and leave the pore spaces open, interconnected, and permeable, whereby the permeability of the article is determined largely by the size of the grains and the relative proportions of grain, bond, and pores.

Porous article of ceramic bonded granular material. W. L. Howe (Norton Co.). U. S. 2,007,052, July 2, 1935 (March 18, 1932).—A porous article of ceramic bonded material comprises highly refractory grains, which upon being heated to the firing temperature of the body are incapable of softening or of any permanent volume change, united by a vitrified glassy bond containing a low percentage of a refractory clay and a much higher content of a low-melting fluxing material which are so constituted and proportioned that the bond is a highly fluid glass at the firing temperature of Seger cone 13 and is free from undissolved material and a vesicular structure, the grains being of coarse size and substantially in contact and the bond being present as a glass in amount sufficient to cement the grains together into an integral porous body which is substantially free from the presence of closed pores, bond posts, and webs between the grains, the major portion of the pore spaces therein between individual grains being open and interconnected, the proportions of the low-melting material in the bond mixture serving to control the fluidity of the bond at the firing temperature of the article, and the permeability of the article being determined largely by the size of the grains and the percentage volume structure of the body, the article being further characterized in that the refractory grains thereof have had their edges and corners rounded so that they are nearly equi-dimensional in all directions, and in that it is a porous structure having a permeability of not less than 4 cu. ft. of air/min./sq. ft. under a pressure head of 2 in. of water.

Roll grinding machine. A. P. Steiner and H. E. Balsiger (Landis Tool Co.). U. S. 2,007,351, July 9, 1935 (Aug. 29, 1929).

Sizing device for grinding machines. Daniel Gurney (Landis Tool Co.). U. S. 2,008,137, July 16, 1935 (Oct. 29, 1931).

Valve-seat grinder. F. O. Albertson (Albertson & Co., Inc.). U. S. 2,005,851, June 25, 1935 (July 19, 1934)

Art and Archeology

Ancient Chinese ware. W. C. White. *Illus. London News*, **186**, 639–41 (April 20, 1935).—Further treasures from the "Elephant" tomb of the 12th Century B.C. at Hsiao-Tu are illustrated. See also *Ceram. Abs.*, **14** [2] 29 (1935). H.H.S.

Charles F. Binns. Anon. *Design*, **36** [7] 16–17 (1935).—A review of the life and work of Charles F. Binns is given. Typical pieces of his ware are illustrated. E.B.H.

Chinaware patterns. Anon. *Arts & Dec.*, **42** [6] 30–33 (1935).—Tableware and colors are described. Illustrated. E.B.H.

Design in the glass industry. E. Maxwell Fry. *Pottery Gaz.*, **60** [697] 865–72 (1935).—Although not familiar with all processes of glassmaking, F. believes that glass should be designed largely to appeal to the masses who buy the cheaper type of glassware; it should meet public demand. True principles of design must be established in machine-made and pressed glass. The public must be educated to the newer designs. Discussion. E.J.V.

Designer's views. K. D. P. Murray. *Jour. Soc. Glass Tech.*, **19** [73] 10–17 (1935).—Continued education of designers and craftsmen is necessary to ensure the maintenance of a high standard of work. Practical work should be encouraged, and mass-produced ware should be made by machine methods wherever possible. A.A.

Eumorfopoulous collection. I. Ceramics. William King. *Connoisseur*, **95** [403] 123–29 (1935).—This collection dates from before the beginning of the Christian era until the middle of the 14th Century A.D. Compared with European ware of the same period, the Oriental pieces indicate the advanced civilization of these people. The finest epoch of mortuary figures and ware was the T'ang Dynasty, A.D. 618 to 906. There are several examples of Ting ware in black and white with ivory glaze. Illustrated. See also "Chinese—" *Ceram. Abs.*, **14** [5] 106 (1935). E.B.H.

First edition china. Anon. *Arts & Dec.*, **43** [2] 30 (1935).—British manufacturers about two years ago asked leading artists to create modern chinaware designs; 27 designs were carried out at Stoke-on-Trent, in limited numbers of signed services. E.B.H.

Glass collections of the Victoria and Albert Museum, London. B. Rackham. *Jour. Soc. Glass Tech.*, **18** [72] 308–22 (1934). A.A.

Glass and good design. William Rothenstein. *Jour. Soc. Glass Tech.*, **19** [73] 5–9 (1935). A.A.

Glasses colored with selenide and sulfide of cadmium used as glazes in ceramic decoration. A. Granger. *Céram., Verrerie, Émail.*, **2** [7] 293–94 (1934); see also "Coloration—" *Ceram. Abs.*, **14** [3] 65 (1935). M.H.B.

Inexpensive glass forms. Anon. *Design*, **36** [7] 27 (1935).—Well-designed machine-made articles within the price means of the masses are now on the market. Early machine work followed handicraft design and decoration, making the processes difficult and the prices high. E.B.H.

Kirk Sandall Hotel, Doncaster. H. A. Johnson. *Jour. Soc. Glass Tech.*, **19** [73] 18–21 (1935).—Glass facings are used both internally and externally. Illustrated. A.A.

Metallizing process for pressed parts on a colloidal basis. Rene W. P. Leonhardt. *Kunststoffe*, **24**, 55–56 (1934).—Methods of metallizing pressed parts for decorative or

electric-conducting purposes are discussed. The well-known shooping process is not suitable for pieces with a smooth surface. L. describes a new process in which the finished parts are first dipped into a solution of hydroquinol, dried, and dipped into a solution of metallic salts, such as 2% gold chloride or 2.5 to 3.0% silver salts. The metallic layer, the thickness of which depends on the number of dippings, may later be polished to a bright finish. L.E.T.

Pennsylvania-Dutch antiques. EDWIN LEFEVRE. *Sat. Eve. Post*, **207** [43] 26–31 (1935).—Before the Declaration of Independence was signed, Baron Stiegel was exhorting the American public to buy American glass because it was as good as the best European glass and lower in price. He produced the best glass of his time and was the first to use lead in this country; he proved that colored and clear flint glass could be made here superior to the imported article. It is almost impossible to authenticate Stiegel glass with the exception of the so-called "Daisy-in-the-Square" bottles, and bowls, salts, or creamers. Pennsylvania-Dutch pottery is also discussed. M.V.C.

Personality in glass. ANON. *Arts & Dec.*, **43** [2] 28–29 (1935).—Decorative glass, the finer pieces of which must be individual, is illustrated. Lindstrand, Gate, Hald, and Maurice Heaton, an American who has invented a glass and method of decoration, are represented. E.B.H.

Ras Shamra (Syria) finds. C. F. A. SCHAEFFER. *Illus. London News*, **186**, 686–90 (April 27, 1935).—Skilfully painted pottery of types hitherto unknown has been found by the French Expedition to ancient Ugarit. 28 photographs. H.H.S.

Relics of Rumanian prehistory, B.C. 2500. D. V. ROSETTI. *Illus. London News*, **186**, 554–55 (April 6, 1935).—Discoveries at Vidra include designs on clay of a Cretan double axe and a potter's mark. See also *Ceram. Abs.*, **14** [1] 2 (1935). H.H.S.

Swedish glassware design. ANON. *Design*, **37** [2] 36–38 (1935).—Illustrated. E.B.H.

Underglaze colors. E. W. T. MAYER. *Trans. Ceram. Soc.* [Eng.], **33** [12] 533–43 (1934).—In dealing with slip and underglaze colors, extreme care must be taken in selecting the materials, standardizing, mixing, calcining, washing, and grinding. Mazarine and mat blue problems are considered in particular. R.H.H.P., JR.

Window glazed with medieval glass fragments. S. E. WINDOLT. *Jour. Soc. Glass Tech.*, **18** [72] 307 (1934). A.A.

BOOKS

China Magnificent. DAGNY CARTER. John Day in association with Reynal & Hitchcock, New York, 1935. xi + 225 pp. 83 illustrations. Price $4.00. This study of five thousand years of Chinese art is divided into three parts. Part I deals with the Age of Magic and Ritual from about B.C. 3000 to A.D. 100. Pottery from stone-age graves and its characteristic symbolic decoration are discussed. Jars and vases found in Han Dynasty graves, the earliest known glazed pieces in China, and the terra cotta grave objects of this period are discussed and illustrated. Part II, the Age of Faith and Splendor, covers the period from A.D. 100 to A.D. 1200. The ceramic work of the T'ang Dynasty is illustrated. Terra cotta grave figures and elaborately decorated pottery are shown. The use of colored glazed tile and ornamental figures in Chinese architecture at this time is also mentioned. Under the Sung Dynasty, according to C., the cultivation of beauty for its own sake led to perfection in many fields of artistic activity. Ceramic pieces of exquisite design, made during this period, are shown. Part III, dealing with the Age of Artisans and Traders, covers the 700 years from A.D. 1200 to the early 20th Century. The political disintegration of the country, the rise of Ming Nationalism, and the development of the porcelain trade and ceramic work under the Manchus are described. In addition to the brief outline of Chinese ceramics, the development of other arts is sketched against a background of significant facts in Chinese history. A general bibliography on Chinese history and civilization, another on Chinese art, and 16 chapter bibliographies are appended. HENRY H. SMITH

Melanesian Design. GLADYS AMANDA REICHARD. Columbia University Press, New York, 1933. Vol. I. x + 172 pp., 75 figs., plate, fold. map. Vol. II. 14 pp. + 151 plates. Price $10.00 (not sold separately). In Melanesia, an area which comprises one comparatively large island, New Guinea, and innumerable small islands, an exuberance of decorative art was developed prior to the breakdown of culture among these people. R. has studied numerous collections of the work of these islanders, for, ironically, the best work of these people is today to be studied in museums, not among the remaining natives. Choosing specimens (1) beautiful from Reichard's point of view, (2) having a fairly wide distribution geographically, (3) overlapping in the occurrence of objects chosen within a given area, and (4) as free as possible from symbolic or religious significance since that may be understood only by questioning the natives, R. presents the general principles underlying a cross-section of Melanesian decorative style. Carved wooden bowls, breast or head ornaments of shell on which tortoise shell is laid (kapkaps), and gourds decorated by burning (these were used for holding chalk) were studied. The woodcarving, tortoise-shell carving with polished shell work, and pyrography are considered to be neither primitive nor strictly utilitarian techniques when used in producing the types of work studied; they belong instead in the realm of "sophisticated" or luxury art. For this reason, R. has proceeded on the assumption that the Melanesian artists were subject to the same impulses which motivate an artisan in contemporary society. It is assumed that the worker has perfect control of tools and material and the interest and energy of each designer has been directed toward individuality of pattern, experimentation, etc., within the limits set by the style to which he is accustomed. Carved wooden bowls from the Admiralty Islands and Tami (Cretin) were studied for form. Their proportions are analyzed and tabulated. Ornamentation is analyzed under the headings of (1) relief carving, including border, bowl wall, and leg decoration, (2) handles, and (3) all-over designs. The examples from Tami are also studied in detail. Of interest to modern designers, familiar with "design piracy," is the attitude of the sibs (family groups) toward their patterns. If a pattern was copied by a member of another sib, a blood feud resulted. Individuals from a given family group are said to be able to recognize works

of their own members at great distances; this recognition is thought to be based largely on close acquaintance with the carver's technique, whether the artist is known personally or his work is known only by reputation. The kapkaps were chosen for study because their occurrence overlaps that of the bowl carvings and gourd decorations. They were widely distributed and appear to be an example of pure decoration without much religious or symbolic significance. As these pieces present varying modes of decoration of a restricted simple surface, a circle, the numerous illustrations in Volume II will be of great interest to ceramic designers. Work coming mainly from the Admiralty Islands and New Ireland was studied. Similar ornaments from Nissan, the Solomon Islands, Santa Cruz, and New Guinea and tortoise-shell rings, ear ornaments, and hairpins from other localities are described. Throughout the sections devoted to analysis and description of the various objects, constant reference is made to the illustrations in Volume II, consequently the two volumes are actually read together. Under the heading of general principles, R. discusses the following design elements used in the pieces she selected to study: (1) triangles, teeth, zigzags, (2) spiral, and (3) realistic designs, (*a*) human figure, (*b*) crocodile, lizard, fish, (*c*) bird. Under the heading of composition, R. outlines the similarities which tend to group certain of these native artists together and the differences which separate to a considerable extent others in this same territory.

This work is considered a pioneering effort in a field of increasing importance because it is rapidly vanishing. The scope of the work is esthetic rather than ethnological, and therefore is of particular value to designers who will find inspiration not only in the illustrations, but also in the intelligent analysis of the work of these native artists.

HENRY H. SMITH

Pueblo Potter. RUTH L. BUNZEL. Columbia University Press, New York, 1929. x + 134 pp. 38 plates. Price $10.00. This work is called on its title page "a study of creative imagination in primitive art." B. spent two years in the pueblos in the southwest United States learning from native potters to make pottery with native tools and to paint it in accordance with native standards in an attempt to discover, among other things (1) the significance of art to primitive man, (2) the way he manipulates the style of his own group to serve his purpose, (3) to what extent the primitive artist is enslaved by tradition and superstition in the exercise of his craft, and (4) whether creative geniuses are found among primitive people and the extent of their influence over their group. Questioning Zuni, Hopi, Acoma, and San Ildefonso potters, B. discovered a variety of attitudes toward the application of designs to the objects, but predominant was the intense, almost continual thought which these artists give to the designs they produce. Typical replies to questions concerning the sources of design are "I am always thinking about designs, even when I am doing other things; whenever I close my eyes I see designs in front of me. I often dream of designs..." "This is a new design. I learned the different parts of it from my mother, but they are put together in a new way. I always make new designs...only those who do not know, copy." Except at Zuni, where designs are built up of recognized elements, B. found that these artists are unconscious of the principles governing the structure of their ornamental designs, and consequently their art is highly susceptible to individual mutation. Decorative style, judging from the statements of these artists and the terminology they employ in speaking of their work, appears to be the product of unconscious and nonrational mental processes. Frequently B. has found a native artist accepting the prevailing style in distinct contradiction to the artist's conscious and expressed intent. To a great extent unaware of the processes determining the character of her designs, the artist's conscious preoccupation is chiefly with matters of technical perfection. Sound structure, regular form, finish, and delicate and regular ornament are stressed in criticizing completed pottery. Typical of the apparent esthetic freedom among these Amerindians is the following statement made to a girl receiving instruction in pottery, "Paint anything you like, only put it on straight."

Stereotypes, B. concludes, are due to that quality of too many human beings, mediocrity, in this case referring to the absence of the creative faculty among many excellent craftsmen. The creative genius in human affairs is compared to the biological sport that effects mutation of the species, an apt comparison. B. distinguishes genius by the ability to experience mentally what has not been experienced sensually and to embody this unique experience in tangible form. This may result in the sudden mutations in style sometimes found. This book is not only an inspiration to designers but is of primary importance to persons dealing with the training of designers. It is a basic contribution to the too little understood field of creative activity.

HENRY H. SMITH

PATENTS

Decalcomania paper. HENRY ATWATER (McLaurin-Jones Co.). U. S. 2,007,630, July 9, 1935 (Feb. 11, 1933). JOHN MACLAURIN. U. S. 2,007,404, July 9, 1935 (Feb. 11, 1933).

Designs for:

Bottle. E. W. FUERST (Owens-Illinois Glass Co.), U. S. 96,105 and 96,106, July 2, 1935 (April 29, 1935). J. H. FUNKEY (Carr-Lowrey Glass Co.). U. S. 96,107, July 2, 1935 (May 4, 1935). J. E. MCLAUGHLIN (Salem Glass Works), U. S. 96,266, July 16, 1935 (April 30, 1935). A. C. MEYER, U. S. 96,045, June 25, 1935 (March 29, 1935). A. C. MEYER (Glenshaw Glass Co.). U. S. 96,267 and 96,268, July 16, 1935 (May 24, 1935).

Bowl. F. P. JUDGE AND E. M. OWENS. U. S. 96,187, July 9, 1935 (Jan. 26, 1935). C. W. OLDHAM (Imperial Glass Corp.). U. S. 96,048, June 25, 1935 (April 12, 1935).

Cabinet for liquid-fuel heaters. W. T. BRADBURY (Florence Stove Co.). U. S. 96,086 and 96,087, July 2, 1935 (May 8, 1935).

Casserole. M. A. SMITH. U. S. 96,141, July 2, 1935 (March 12, 1935).

Goblet. C. R. KEIL (United States Glass Co.). U. S. 96,119 to 96,121, July 2, 1935 (March 29, 1935).

Jug. W. O. PROUTY (Metlox Mfg. Co.). U. S. 96,274, July 16, 1935 (April 26, 1935). FRASIER SMITH (Hazel-Atlas Glass Co.). U. S. 96,142, July 2, 1935 (April 22, 1935).

Perfume bottle. A. R. Botham (Coty, Inc.). U. S. 96,089, July 2, 1935 (April 15, 1935).

Plate. J. E. Goodwin (Josiah Wedgwood & Sons, Inc., of America). U. S. 96,178 to 96,180, July 9, 1935 (April 24, 1935), and U. S. 96,247, July 16, 1935 (April 24, 1935). F. P. Judge and E. M. Owens U. S. 96,186, July 9, 1935 (Jan. 26, 1935). C. W. Oldham (Imperial Glass Corp.). U. S. 96,132, July 2, 1935 (March 29, 1935).

Cements

Determining free lime in cement. V. Rodt. *Zement*, **23**, 605–609 (1934); abstracted in *Chem. Zentr.*, **i**, 613 (1935).—Methods for determining free lime in cement are compared as to results obtained and efficiency.

M.V.C.

Development of proposed standards and tests for plaster of Paris in the ceramic industries. Samuel J. McDowell. *Bull. Amer. Ceram. Soc.*, **14** [7] 229–36 (1935).

Direct determination of alkalis in Portland cement. A. A. Berk and P. S. Roller. *Concrete (Cement & Mill Section)*, **43**, 38–39 (1935); *Chem. Abs.*, **29**, 3484 (1935).—After decomposition of the cement with 1:1 HCl solution and elimination of the main body of SiO_2, K and Na are determined in the filtrate. K is precipitated as chloroplatinate and the latter is reduced with Mg wire to Pt which is weighed. Na is precipitated from a separating aliquot with uranyl Zn acetate and weighed as the Na salt of this compound.

High-lime Portland cements. III. Chrome cement. Seiji Kondo and Hiroshi Yoshida. *Jour. Jap. Ceram. Assn.*, **43** [505] 5–10 (1935).—Five groups of Portland cement were prepared and examined for small-piece strength. A part of alumina, ferric oxide, and silica in each base composition was replaced by chromic oxide. In every group, chromic oxide promoted usual 1- to 28-day strength as well as combined 4-week strength. The effect of the oxide varied with the proportions of the other constituents. White and green high early-strength cements were obtained with limestone, pyrophyllite, and chromic oxide. For Part I see *Ceram. Abs.*, **12** [4] 141 (1933). S.K.

Magnesia content of Portland cement. II. Yoshiaki Sanada and Gunkichi Nishi. *Jour. Jap. Ceram. Assn.*, **43** [506] 75–79 (1935).—Linear expansion, tensile strength, and compressive strength of bars, made of the neat cements and 1:3 mortars and cured in fresh and sea water for 3 days to 1 year, were measured with the following results: (1) In fresh water, the expansion increased with age, the effect of the magnesia content being slight; in sea water, the expansion was greater. (2) The tensile strength was not decreased up to 1 year, while the compressive strength attained its maximum at 1 to 6 months. The reduction of the compressive strength was greater in sea water than in fresh water. See also *Ceram. Abs.*, **12** [4] 141 (1933).

S.K.

Mixed Portland cements. XIII. Shoichiro Nagai and Keima Matsuoka. *Jour. Jap. Ceram. Assn.*, **43** [508] 215–27 (1935).—Experiments were made with mixed Portland cements to which much lime had been added. The cements were composed of Portland cement clinker 50 to 60, siliceous material, such as spent shale of the oil-shale industry, siliceous earths, calcined shale of Fushun in Manchukuo 20 to 30, and quick or slaked lime 10 to 20. The mixtures were ground fine. The results were as follows: (1) The cements set as quickly as Portland cement, or more quickly. (2) With the dry-mortar test method, the cements hardened better than Portland cement on curing 28 days and longer. With the wet-mortar test method, the cements showed more rapid rate of hardening than Portland cement. (3) Linear expansion of sand mortars on water curing and contraction on combined curing were nearly equal to or a little less than those of Portland cement. See also *Ceram. Abs.*, **9** [10] 823 (1930). S.K.

PATENTS

Apparatus for treating raw materials for the manufacture of cement. M. Vogel-Jorgensen. Brit. 430,430, July 3, 1935 (Dec. 19, 1933).

Manufacture of cement. C. H. Breerwood (Valley Forge Cement Co.). U. S. 2,006,939, July 2, 1935 (June 5, 1934).

Method and composition for retarding the setting time of Portland cement. J. E. Weiler. U. S. 2,006,426, July 2, 1935 (December 5, 1934).—A method of forming fluid hydraulic cement slurries adapted to be used in well cementing operations, the slurries having a retarded setting time at temperatures above atmospheric, comprises the steps of forming a hydraulic cement slurry containing a water-soluble boron compound and a water-soluble gum in addition to hydraulic cement and water.

Water and weather-proofing magnesia cement. Fred Ottman. U. S. 2,008,034, July 16, 1935 (March 26, 1934).—A method of preparing an emulsion to be used in making magnesia cement consists in first pepticizing water-insoluble metallic soap cold in a small quantity of a fatty oil, intermingling therewith a solution of a metallic salt intended to act as binder for the cement and a suitable emulsifying agent, while agitating, and finally adding to the emulsion so obtained a small amount of a caustic alkali with resumed agitation, to act as stabilizer for the emulsion.

Enamel

Accelerated weathering tests on porcelain enamel. M. G. Ammon. *Enamelist*, **12** [9] 8–10 (1935).—The Weather-O-Meter, a device for making accelerated weathering tests, is described. By means of light and water sprays it is possible to simulate varied conditions of weather. Results of tests are given in tabulated form. Results obtained on the accelerated tests on porcelain enamel show that this method is not severe enough for good comparisons of different porcelain enamels, but that porcelain enamels have many times more weather resistance than organic protective coatings. Illustrated.

E.J.V.

Acid-resistance specification for enameled hollow ware. J. H. Coste and D. C. Garratt. *Analyst*, **60**, 215–19 (March, 1935).—The test for cooking vessels for use in public institutions under the London County Council is as follows: fill the vessel with boiling 0.5% solution of citric acid in water, allow to stand for 24 hr., evaporate the solution, and ignite the residue; repeat the test. The ash shall not exceed 1 mg./sq. cm. of surface exposed to acid on the first treatment and 0.5 mg. on the second treatment. H.H.S.

Adherence of ground enamels containing cobalt and nickel oxides. II. Friedrich Heimes. *Sprechsaal*, **67** [47] 720–22 (1934).—Attempts to determine potentials appearing in enamel melts are described. Iron electrodes were used. Additions of melts containing NiO and CoO yielded marked but varying results. Oxygen of the surrounding atmosphere has a great influence on the formation of local currents in the enamel melt. For Part I see *Ceram. Abs.*, **13** [11] 284 (1934). M.V.C.

Antimony compounds extracted from enamelware by citric acid solutions. R. H. Burns. *Analyst*, **60**, 220–22 (March, 1935).—Sb_2O_3 and Sb_2O_5 are soluble in citric acid; Sb_2O_4 is not. The enamel used for testing contained 0.98% total Sb. Nearly one-tenth of this was dissolved in 498 hr. by 0.5% citric acid in 5 extractions. Cleaning or scouring vessels exposes a new surface to attack. The total prohibition of Sb in enamelware is advocated. H.H.S.

Calculation of the coefficients of expansion of silicate glasses applied to ceramic enamels. A. C. *Rev. mat. constr. trav. pub.*, No. 307, pp. 49–52B (1935).—The results of the work of Gilard and Dubrul (*Ceram. Abs.*, **13** [9] 232 (1934)) are discussed, and their application to enamels is pointed out. M.V.C.

Cerous oxide as opacifier. Vielhaber. *Emailwaren-Ind.*, **12** [17] 140 (1935).—Studies on cerous oxide as an opacifier for enamels have never been made. It is known, however, that cerous oxide (1) has an action similar to that of silica in glass, and (2) may be used as an opacifier in glass but is uneconomical. If cerous oxide could be added to the mill, its opacifying effect would be much greater. M.V.C.

Colorimetric determination of silicon in ordinary cast iron. A. Travers. *Bull. Assn. Tech. Fonderie*, **8**, 345 (1934); abstracted in *Chem. Zentr.*, **i**, 601 (1935). M.V.C.

Decorative effects in enamel. Vielhaber. *Emailwaren-Ind.*, **12** [1] 1–2 (1935).—Brief directions are given. M.V.C.

Effect of furnace gases on ground-coat enamels. W. C. Cummings. *Jour. Can. Ceram. Soc.*, **4**, 52–54 (1935); for abstract see "Pitting—," *Ceram. Abs.*, **14** [4] 88 (1935). J.G.P.

Enamel abstracts. Anon. *Glashütte*, **65** [9] 145–50 (1935).—A series of abstracts dealing with the latest researches in the field of enamels is given. References are included. M.V.C.

Enamel defects prevented by firing in inert gas atmosphere. Wesley G. Martin. *Ceram. Ind.*, **25** [1] 20–21 (1935).—An enamel covering is fused to a metal base in an atmosphere which is substantially inert or nonreactive with respect to the enamel and metal, instead of in air. There is substantially no blistering or copperheading. It is possible to effect economies by the use of less expensive material than the grades of enameling iron and steel now used. The method also provides for the application of enamel coatings to the higher carbon steels and the production of enameled articles having a base of greater strength than the low-carbon steels now used. It further facilitates the application of enamels to cast iron. E.J.V.

Enamel as a protection against corrosion and for improving metallic surfaces. Ludwig Stuckert. *T. Z. prakt. Metallbearb.*, **44** [3–4] 72–74 (1934); abstracted in *Chem. Zentr.*, **i**, 610 (1935).—A review is given of (1) enamel compositions, (2) adherence, (3) firing, (4) opacifying, and (5) composition of ordinary opacifiers and colorizers. See *Ceram. Abs.*, **14** [1] 5 (1935). M.V.C.

Enamel shop troubles. R. Atkinson. *Jour. Can. Ceram. Soc.*, **4**, 57–58 (1935).—Three cases of blistering in cast-iron enameling are cited, and methods of overcoming the trouble are described. J.G.P.

Enamel technical observations and studies. Walter Obst. *Emailwaren-Ind.*, **12** [5] 35–36 (1935).—American studies on (1) the effect of water on the viscosity and coating power of enamel, (2) ground enamel, (3) adherence of enamel, and (4) iron oxide layer in the ground enamel are briefly discussed. M.V.C.

Enameled washing machine tanks. P. R. Bachman. *Sheet Metal Ind.* [London], **11** [95] 164 (1935); abstracted in *Emailwaren-Ind.*, **12** [18] 147–48 (1935).—A brief description is given of the enameling of washing-machine tanks by the Youngstown Pressed Steel Co. M.V.C.

Enameling cast-iron ware and kettles. H. J. Karmaus. *Sprechsaal*, **67** [45] 688–91 (1934).—Enamel batches are given and their properties are discussed. M.V.C.

Enameling cast iron by the wet method. H. Lang. *Glashütte*, **65** [1] 8–11 (1935).—Enameling ware with a fritted ground, fused ground, water ground, and without ground enamel is described in detail. Methods for enameling cast iron by the wet method are dealt with. See also *Ceram. Abs.*, **14** [1] 5 (1935). M.V.C.

Enameling sheet iron in one or two firings. Richard Aldinger. *Glashütte*, **65** [9] 140–43 (1935).—Methods for enameling sheet-iron ware in one firing or a repeated firing are discussed. Directions are given for obtaining black, colored, gray, white, and spotted ground enamels in one firing, and other enamels with a repeated firing. M.V.C.

Factors affecting the proper firing of porcelain enamel on steel or iron. H. B. Ebright and G. H. McIntyre. *Ind. Heating*, **2** [6] 293–98 (1935).—Porcelain enamels are true silicate glasses fused to a steel or iron base at temperatures of 1200 to 1700°F. Tests are described which reveal the importance of proper atmospheric and temperature conditions in the furnace if defects such as scumming, blistering, and copperheading are to be avoided; they may be due to foreign gases in the furnace. The individual points to be observed are briefly discussed. M.H.

Fluorides in enamels. L. Vielhaber. *Emailwaren-Ind.*, **12** [9] 69–70 (1935).—The main fluorides used in enameling are cryolite (natural and synthetic), sodium fluosilicate, fluorspar, and, less often, sodium fluoride and chiolite. Part of the fluorine is lost in the form of gases.

(SiF_4, BF_3, and AlF_3) during melting. Nickel and cobalt fluorides are also volatile. Cryolite and sodium fluosilicate produce NaF, an opacifier currently used. Fluorides are used as fluxes and as opacifiers. The former must be more fusible than the other constituents of the enamel; the latter must melt above 1000°, be chemically stable, and be capable of being reprecipitated if they are fused. This precipitation depends on the rate of cooling. To promote opacification, the cooling must be slow. The fusing points of the principal fluorides are given. M.V.C.

Mechanics of enamel suspension. II. Electrodialysis of enamels and glasses. R. M. KING. *Jour. Amer. Ceram. Soc.*, **18** [8] 230–33 (1935); for Part I see *Ceram. Abs.*, **14** [6] 134 (1935).

Nickel dip in enameling practice. J. E. HANSEN AND J. T. IRWIN. *Jour. Amer. Ceram. Soc.*, **18** [8] 225–29 (1935).

Patents on enamels. PHILIPP EYER. *Glashütte*, **65** [9] 143–45 (1935).—A list of patents related to enamels, issued in Germany since the War, is given. M.V.C.

Porcelain enamel in outdoor advertising. H. EDWARD WINTER. *Enamelist*, **12** [9] 24–25 (1935).—The possibility of producing posters, signs, and billboards of porcelain enameled sheets with colored pictures produced by the silk-screen reproduction process is suggested. The ability of porcelain enamel to withstand all atmospheric conditions makes this material suitable and highly practical for outdoor advertising. Illustrated. E.J.V.

Reboiling of ground coats. W. A. IRVINE. *Jour. Can. Ceram. Soc.*, **4**, 46–52 (1935).—Literature on the results obtained during the preceding two years in the investigations on the phenomena connected with reboiling of sheet-iron ground coats is reviewed. No definite conclusion has been drawn as to what causes reboiling or what will eliminate it. Some condition in the iron is largely the cause of the reboil and yet this is not sufficient to explain all of its peculiarities. Two sets of conditions may exist at the same time, *i.e.* (1) in the iron and (2) a reaction between iron and enamel. This would explain some of the anomalous behavior of both metals and enamels that has been observed. It is now doubtful whether it is desirable to remove the reboiling tendency completely. Recent work tends to confirm previous observations that reboiling seems to be related in some way to adherence. Almost invariably absence of reboiling or a slight tendency to reboil is associated with poor adherence. Reboiling should be controlled to a point at which it will cause negligible losses in practice and at the same time not sacrifice the essential quality of adherence. J.G.P.

Replacing boric acid in enamel. RICHARD ALDINGER. *Glashütte*, **65** [3] 31–33 (1935).—The decrease of the boric acid content in an enamel batch may be theoretically equalized by (1) an increased addition of alkalis in the form of soda, potash, or saltpeter, (2) increased addition of alkaline earth in the form of carbonate of lime or barium or strontium carbonate or nitrate, (3) addition of fluorspar, (4) cryolite, (5) sodium fluosilicate, (6) lead oxide in the form of minium or litharge; (7) increased use of zinc oxide, (8) addition of sodium phosphate, (9) introduction of low-melting sodium silicates, glass powder, and other glass compositions instead of quartz and feldspar. The advantages and disadvantages of using these additions and substitutes are discussed in detail. M.V.C.

"Roughening" the surface of sheet iron. L. VIELHABER. *Emailwaren-Ind.*, **12** [9] 71–72 (1935).—Attempts to "roughen" the surface of sheet iron, by the use of indirect current, to apply a white enamel directly on it are discussed. An ordinary white enamel was applied on the treated surface. Bending tests showed, however, that the enamel adhered poorly. M.V.C.

Theory of blistering of cast-iron enamels. H. D. MCLAREN. *Jour. Can. Ceram. Soc.*, **4**, 54–55 (1935).—Causes and methods of prevention of blistering of cast-iron enamels are discussed. J.G.P.

Tonometer. Study of color and brightness of white films. L. A. WETLAUFER. *Ind. Eng. Chem., Anal. Ed.*, **6** [5] 376–79 (1934).—An instrument for the measurement of yellowness in white enamel films is described. It may be used (1) for studying the initial yellowness and brightness of white enamels and for classifying them with respect to other hues which may be present, (2) for the study of white enamel aging with respect to these properties, (3) for determining the effect of temperature variation, (4) for determining stability as to yellowness and brightness, and (5) for measuring the effect of variations in enamel film application caused particularly by differences in enamel film thickness. Illustrated. F.G.H.

PATENTS

Enameling iron. IGNAZ KREIDL. Austrian 140,849, Feb. 25, 1935; *Chem. Abs.*, **29**, 4146 (1935); addition to 136,003 (*Ceram. Abs.*, **13** [10] 252 (1934)).—The adhesion of the enamel is promoted by plating the Fe with Fe-Ni or Fe-Co alloy.

Enameling iron. IGNAZ KREIDL. Ger. 609,165, Feb. 8, 1935; *Chem. Abs.*, **29**, 3128 (1935); see Austrian 136,003.

Enameling iron. WIENER EMAIL- UND GLASURFABRIK SCHAUER & CO. Austrian 140,233, Jan. 10, 1935; *Chem. Abs.*, **29**, 3128 (1935).—Use is made of a mixture of a frit with a readily fusible enamel. The frit may be an ordinary refractory frit containing, *e.g.*, quartz 40, kaolin 30, and borax 30 parts, or a frit which contains more alkali and fuses superficially at the firing temperature may be used. The mixture may also contain a pigment. Only one application of the mixture and only one firing are necessary.

Sink. R. E. CRANE AND L. G. PROBST. U. S. 2,008,349, July 16, 1935 (July 30, 1932).

Glass

Architectonic element in stained-glass windows. III. JACQUES WOLF. *Verre & Silicates Ind.*, **6** [10] 185–86 (1935).—The original legendary stained-glass windows were no more than tiers of medallions with decorative borders and networks with flower and leaf motifs. When large figures were first introduced, the general contour of a frame was kept, but gradually the flower and leaf borders gave place to architectural elements such as columns and arches. W. cites examples of stained-glass windows which show this transition. Diagrams are given. For Part II see *Ceram. Abs.*, **14** [3] 64 (1935). M.V.C.

Borax product. W. RONALD LESTER. *Glass Ind.*, **16**

[7] 216–17 (1935).—Pyrobor is a dehydrated borax prepared for the more advantageous introduction of B_2O_3 or $Na_2B_4O_7$ into glass batches. Comparative tests with Pyrobor and borax show that the former has the following advantages: (1) puffing is eliminated; (2) "fluxing action" is much quicker; (3) strong and early fluxing action of Pyrobor decreases the tendency to scum formation; (4) less heat is required to melt Pyrobor; (5) glass containing it "fines" more rapidly; (6) because of higher bulk density of Pyrobor (82 lb./cu. ft. as against 63 lb./cu. ft. for borax) less storage space is required. Illustrated. E.J.V.

Colored, fire-polished, opaque glass. ANON. *Sprechsaal*, **67** [48] 731–32; [49] 747–48 (1934).—The advantages of colored, fire-polished, opaque glasses over glazed tile and their use are dealt with. The composition, melting, and production of large panes of opaque glass are described. M.V.C.

Colored glasses. LUDWIG SPRINGER. *Glashütte*, **65** [9] 150–51 (1935).—Differences between oxidic pigments (whose elements are introduced into the glass as oxygen compounds) and elementary pigments (which color the glass directly) are dealt with, and the composition of violet, blue, green, yellow, orange, red, gray, and black glasses is discussed. M.V.C.

Cullet. CARL J. UHRMANN. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; *Glass Ind.*, **16** [7] 200–201 (1935).—Cullet is extremely difficult to keep clean, so best results are obtained by circulating the cullet as rapidly as possible. Crushed cullet should be run through a magnetic separator before using, since stray or tramp iron frequently gets into the material, particularly from the crusher. E.J.V.

Effect of temperature treatment on glass-to-metal seals. J. T. LITTLETON. *Jour. Amer. Ceram. Soc.*, **18** [8] 239–45 (1935).

Effect on the viscosity and surface tension of molten soda-lime-silica glass of the addition of small amounts of volatile salts. A. E. J. VICKERS, J. A. SUGDEN, AND R. A. BELL. Abstracted in *Atti I° congr. internat. vetro e ceram.*, p. 679 (1933).—The increased rate of "fining" of glass obtained when small quantities of volatile salts are added to the batch may be due to the effect which these have on the viscosity and surface tension of the molten glass. Apparatus for measuring both viscosity and surface tension at high temperatures was devised. Experiment shows that the influence of small quantities of volatile salts upon viscosity is in general small, being most marked at temperatures normally used in founding the glass. Below the founding temperature the viscosity was increased slightly, and at temperatures above normal the viscosity was decreased when volatile salts were added. At temperatures within the normal working range of the glass, the addition of volatile salts lowered the viscosity. The effect of volatile salt additions on surface tension is not marked except in special instances, *i.e.*, ammonium sulfate with a low temperature of founding shows an increase in surface tension but not with a high temperature; sodium nitrate and borax show increased surface tension at high temperatures. Certain gases had a marked influence on the fining of glass, *i.e.*, it seems impossible to fine glasses used in these experiments in the presence of hydrogen. Well-fined glasses seemed to dissolve hydrogen readily.

Electric furnace in the glass industry. H. GREMPE. *Glas & App.*, **16** [12] 107 (1935).—The advantages of an electric furnace for making hard glass with a melting point of about 1500°C are discussed with respect to closeness of temperature and atmosphere control, tempering in the furnace, and hygienic conditions. A furnace of 600-kw. capacity is given as an example. M.H.

Electrical conductivity of borate glasses of low alkali content. R. MYULLER AND B. MARKIN. *Acta Physicochim.* [U.R.S.S.], **1**, 160–67 (1934) (in German); *Chem. Abs.*, **29**, 2804 (1935).—The existence of the polarization phenomenon is determined by comparison at temperatures at which the specific electrical conductivities, κ, are equal. The temperatures corresponding to given values of κ for glasses containing, respectively, 2.6 and 25% Na_2O are 4×10^{-6} at — and 328°; 5×10^{-7} at 447° and 243°; 10^{-10} at 317° and 72°; 4×10^{-13} at 258° and —. Polarization phenomena are not shown by these glasses at 317° and 72°, respectively, or below. Glasses with less than 5.5% Na_2O do not show polarization because the effect, due to low κ values, is observable only at temperatures above the softening range or after a very long time. The conductivity of borate glasses is an ionic, not an electronic, conductivity. On this assumption the observed κ for Merck's *Acidicum boricum fusum pro analysi* indicates a Na_2O content of 0.002 mol. per cent.

English or Irish? W. B. HONEY. *Connoisseur*, **95** [402] 77–80 (1935).—There is little positive evidence of the special character of any local productions of glass. In about 1780, Irish glass began to play an important part in the markets of Great Britain, especially because of the excise duties laid upon English makers. Color and decolorizers are discussed. Ravenscroft's lead glass (1672), cut brilliantly but not elaborately, was used until about 1770. Old glass, unlike china, is often remelted, accounting for the scarcity of antique pieces. Illustrated. E.B.H.

Feldspar in the glass industry. WILHELM SCHMIDT. Translated in *Glass Ind.*, **16** [7] 219–20 (1935); see "Ground—" *Ceram. Abs.*, **14** [5] 111 (1935). E.J.V.

Free alkali in glass. L. F. GABEL. *Jour. Amer. Pharm. Assn.*, **23**, 1174–77 (1934); *Brit. Chem. Abs.*, **54** [11] 227*B* (1935).—Ampoules or bottles to be tested are filled with freshly boiled distilled H_2O (p_H approximately 5.6 by Me-red) and kept at 80 to 90° for 16 hr. The resulting liquid is cooled and tested with bromothymol-blue or cresol-red, the increase in p_H being a criterion of the relative suitability of the glass.

Fuels in glass furnaces, their equivalents, and the problem of nonluminous flame heating. D. B. GINZBURG. *Keram. i Steklo*, **11** [3] 20–28 (1935).—Data on the composition and properties of various fuels for glass furnaces in U.S.S.R. are given. M.V.C.

Gas-tight joints and current inlets in ceramic materials. SCHAD. *Glas & App.*, **15** [7] 49–50 (1934); **16** [11] 97–98 (1935).—Joints of ceramic materials are best made by slipping a glass tube of good fit over the two ends and heating the joint beyond the softening point of the glass by a torch or electrically; the glass should have a slightly lower thermal expansion coefficient than the ceramic material. In a similar manner, wires or electrodes are fused into a ceramic material by first fusing them into a

glass tube and then fusing the glass into the ceramic body. Massive wires are advantageously replaced by metallic films deposited on a ceramic body of the same mass into which the wire, etc., is to be fused; as the films have a much greater surface and are quite thin, the expansion by heat is considerably less than for the solid wire. M.H.

Glass analysis by the treatment of thin film in the autoclave. I. Determination of soda. A. R. Wood. *Jour. Soc. Glass Tech.*, **19** [73] 22–39 (1935).—Glass films, blown from a platinum alloy tube, had a thickness of only 1μ and hence exposed a large surface to a liquid reagent. These films were treated with various reagents to dissolve out the soda, when the latter was estimated by titration. Glasses ranging in soda content from 9 to 22% were heated in the autoclave at temperatures up to 217°C (corresponding to 300 lb./sq. in.). Water, solutions of sodium hydroxide, carbonate, borate, and phosphate, and calcium and barium hydroxides were used as solvents. Methyl orange was found to be the most satisfactory indicator for titrating the soda. Hydrolysis of calcium and magnesium silicates and their absorption of soda caused difficulties. Details of a procedure are given whereby the soda content of a window glass was obtained to within 0.2%, but to ensure this accuracy it was essential to follow the method exactly and to use 0.08 g. of film in 50 ml. of water. The treatment with water was for 1 hr. at 200°, and the resultant solution was filtered rapidly to avoid hydrolytic action. The determination in every case must be made on a freshly-blown sample of film. A.A.

Glass and its composition. L. Springer. *Glashütte*, **65** [12] 193–94 (1935).—A brief review is given of the properties of quartz glass, water glass, and technical glass and of the differences between them. M.V.C.

Glass electrode determination of p_H. V. Mantere. *Acta Chem. Fennica*, **7A**, 119–21 (1934); abstracted in *Chem. Zentr.*, **i**, 1094 (1935).—A review. M.V.C.

Glass electrodes for p_H measurements in biological liquids. G. Haugaard. *Biochem. Z.*, **274**, 231–52; abstracted in *Chem. Zentr.*, **i**, 933 (1935). M.V.C.

Glass ink. Ziener. *Glas & App.*, **16** [12] 112 (1935).—A new ink in all colors is said to dry in a few minutes and to stand temperatures up to 500° and even 1000°C without fading. It does not contain HF and is not dangerous in use. The composition is not given. M.H.

Glassblowing with the torch by means of patterns. O. G. Eiternick. *Glas & App.*, **16** [13] 117–19 (1935).—The new practice is described by which complicated or hollow glass parts for instruments and chemical apparatus are made by blowing the glass round a pattern or core. Materials for the pattern are soapstone or a mixture of magnesia, asbestos, and pulverized wood; the latter is cast like gypsum and hardens in 36 hr. About 800 to 1000 pieces can be made with it. Iron and red-brass patterns have also been used, but the most satisfactory material for resisting the high temperatures is pure carbon. The technique of making the pattern and forming the glass is described. M.H.

Glasses. Bernard Long. *Verre & Silicates Ind.*, **6** [9] 158–65; [10] 177–84 (1935).—Modern glasses are grouped as (1) industrial glasses used for the manufacture of products of common usage and large-scale consumption, such as bottles, electric bulbs, window glass, and plate glass, and (2) special glasses, *e.g.*, laboratory, optical, opal, and colored signal glasses. The achievements in the latter group from the application of science have been far in advance of the development of the former branch because of the slowness of industrialists to realize the importance of physicochemical studies on glasses. In the last 20 years, the extensive use of the tank furnace for fusing glass and automatic machines for working it has brought about a considerable evolution in the glass industry. Some of the effects of a better knowledge of the problems of viscosity and devitrification are explained. A concise description of the kinds of industrial and special glasses is given. M.V.C.

Heating up a glass tank furnace. Z. C. Kline. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; *Glass Ind.*, **16** [7] 209–13 (1935).—In heating up glass tanks, the limiting factor is the clay block, not the silica brick. K. recommends starting with a low temperature and testing the block with the bare hands in the beginning to determine how uniformly the tank is being heated. A heating curve followed in practice at Pitney Glass Works, Niles, Ohio, is discussed. E.J.V.

Influence of some batch constituents on the color of glass. E. J. C. Bowmaker. *Jour. Soc. Glass Tech.*, **19** [73] 40–42 (1935).—The substitution of 2% of barium oxide for an equivalent amount of calcium oxide necessitated an increase of about 30% in the selenium required to decolorize the resulting glass. A 30% addition of cullet caused an increase of 25% in the selenium, whereas 40 lb. of borax/1000 lb. of sand in the batch reduced the selenium required by 25%. The batches, which are given, were used in actual practice for the production of bottle glass which contained 0.05% Fe_2O_3 in each case. A.A.

Installation for the manufacture of cast glass by fusion in a tank furnace. W. Sauerland. *Glashütte*, **65** [8] 115 (1935); abstracted in *Verre & Silicates Ind.*, **6** [11] 208 (1935).—S. explains the inconveniences of the present processes of manufacturing special glasses and plate glass in tank furnaces. A new method which remedies many disadvantages is described. The tank furnace for fusing is relatively short with two burners; the flames are directed toward the charging end. Two barriers separate the glass in the fusing compartment from that at the place where it is taken out to be worked. The outlet is relatively small and serves only to permit the glass to be drawn off by means of a reservoir of rectangular form. The back of the latter is formed of inclined walls leaving a rather small opening. The whole forms an air-tight chamber which can be connected with flexible pipes to a vacuum pump or a compressor. For filling, the lower edges of the reservoir are immersed about 60 mm. into the glass of the tank; then, under the action of the vacuum, the glass is drawn up to fill the space left for it. The whole thing, being attached to a rolling bridge, can be brought in front of the cylinder of a casting table. The interior of the reservoir is again connected with atmospheric pressure and the glass runs out from the bottom in front of the cylinder. When the pouring is ended, a mixture of gas and air is introduced into the reservoir; it ignites and eliminates waste glass adhering to the walls. M.V.C.

Insulation of glass-furnace regenerators. J. E. Mc-

[7] 216–17 (1935).—Pyrobor is a dehydrated borax prepared for the more advantageous introduction of B_2O_3 or $Na_2B_4O_7$ into glass batches. Comparative tests with Pyrobor and borax show that the former has the following advantages: (1) puffing is eliminated; (2) "fluxing action" is much quicker; (3) strong and early fluxing action of Pyrobor decreases the tendency to scum formation; (4) less heat is required to melt Pyrobor; (5) glass containing it "fines" more rapidly; (6) because of higher bulk density of Pyrobor (82 lb./cu. ft. as against 63 lb./cu. ft. for borax) less storage space is required. Illustrated. E.J.V.

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Gas-tight joints and current inlets in ceramic materials. SCHAD. *Glas & App.*, **15** [7] 49–50 (1934); **16** [11] 97–98 (1935).—Joints of ceramic materials are best made by slipping a glass tube of good fit over the two ends and heating the joint beyond the softening point of the glass by a torch or electrically; the glass should have a slightly lower thermal expansion coefficient than the ceramic material. In a similar manner, wires or electrodes are fused into a ceramic material by first fusing them into a

glass tube and then fusing the glass into the ceramic body. Massive wires are advantageously replaced by metallic films deposited on a ceramic body of the same mass into which the wire, etc., is to be fused; as the films have a much greater surface and are quite thin, the expansion by heat is considerably less than for the solid wire. M.H.

Glass analysis by the treatment of thin film in the autoclave. I. Determination of soda. A. R. Wood. *Jour. Soc. Glass Tech.*, **19** [73] 22–39 (1935).—Glass films, blown from a platinum alloy tube, had a thickness of only 1μ and hence exposed a large surface to a liquid reagent. These films were treated with various reagents to dissolve out the soda, when the latter was estimated by titration. Glasses ranging in soda content from 9 to 22% were heated in the autoclave at temperatures up to 217°C (corresponding to 300 lb./sq. in.). Water, solutions of sodium hydroxide, carbonate, borate, and phosphate, and calcium and barium hydroxides were used as solvents. Methyl orange was found to be the most satisfactory indicator for titrating the soda. Hydrolysis of calcium and magnesium silicates and their absorption of soda caused difficulties. Details of a procedure are given whereby the soda content of a window glass was obtained to within 0.2%, but to ensure this accuracy it was essential to follow the method exactly and to use 0.08 g. of film in 50 ml. of water. The treatment with water was for 1 hr. at 200°, and the resultant solution was filtered rapidly to avoid hydrolytic action. The determination in every case must be made on a freshly-blown sample of film. A.A.

Glass and its composition. L. Springer. *Glashütte*, **65** [12] 193–94 (1935).—A brief review is given of the properties of quartz glass, water glass, and technical glass and of the differences between them. M.V.C.

Glass electrode determination of p_H. V. Mantere. *Acta Chem. Fennica*, **7A**, 119–21 (1934); abstracted in *Chem. Zentr.*, **i**, 1094 (1935).—A review. M.V.C.

Glass electrodes for p_H measurements in biological liquids. G. Haugaard. *Biochem. Z.*, **274**, 231–52; abstracted in *Chem. Zentr.*, **i**, 933 (1935). M.V.C.

Glass ink. Ziener. *Glas & App.*, **16** [12] 112 (1935).—A new ink in all colors is said to dry in a few minutes and to stand temperatures up to 500° and even 1000°C without fading. It does not contain HF and is not dangerous in use. The composition is not given. M.H.

Glassblowing with the torch by means of patterns. O. G. Eiternick. *Glas & App.*, **16** [13] 117–19 (1935).—The new practice is described by which complicated or hollow glass parts for instruments and chemical apparatus are made by blowing the glass round a pattern or core. Materials for the pattern are soapstone or a mixture of magnesia, asbestos, and pulverized wood; the latter is cast like gypsum and hardens in 36 hr. About 800 to 1000 pieces can be made with it. Iron and red-brass patterns have also been used, but the most satisfactory material for resisting the high temperatures is pure carbon. The technique of making the pattern and forming the glass is described. M.H.

Glasses. Bernard Long. *Verre & Silicates Ind.*, **6** [9] 158–65; [10] 177–84 (1935).—Modern glasses are grouped as (1) industrial glasses used for the manufacture of products of common usage and large-scale consumption, such as bottles, electric bulbs, window glass, and plate glass, and (2) special glasses, *e.g.*, laboratory, optical, opal, and colored signal glasses. The achievements in the latter group from the application of science have been far in advance of the development of the former branch because of the slowness of industrialists to realize the importance of physicochemical studies on glasses. In the last 20 years, the extensive use of the tank furnace for fusing glass and automatic machines for working it has brought about a considerable evolution in the glass industry. Some of the effects of a better knowledge of the problems of viscosity and devitrification are explained. A concise description of the kinds of industrial and special glasses is given. M.V.C.

Heating up a glass tank furnace. Z. C. Kline. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; *Glass Ind.*, **16** [7] 209–13 (1935).—In heating up glass tanks, the limiting factor is the clay block, not the silica brick. K. recommends starting with a low temperature and testing the block with the bare hands in the beginning to determine how uniformly the tank is being heated. A heating curve followed in practice at Pitney Glass Works, Niles, Ohio, is discussed. E.J.V.

Influence of some batch constituents on the color of glass. E. J. C. Bowmaker. *Jour. Soc. Glass Tech.*, **19** [73] 40–42 (1935).—The substitution of 2% of barium oxide for an equivalent amount of calcium oxide necessitated an increase of about 30% in the selenium required to decolorize the resulting glass. A 30% addition of cullet caused an increase of 25% in the selenium, whereas 40 lb. of borax/1000 lb. of sand in the batch reduced the selenium required by 25%. The batches, which are given, were used in actual practice for the production of bottle glass which contained 0.05% Fe_2O_3 in each case. A.A.

Installation for the manufacture of cast glass by fusion in a tank furnace. W. Sauerland. *Glashütte*, **65** [8] 115 (1935); abstracted in *Verre & Silicates Ind.*, **6** [11] 208 (1935).—S. explains the inconveniences of the present processes of manufacturing special glasses and plate glass in tank furnaces. A new method which remedies many disadvantages is described. The tank furnace for fusing is relatively short with two burners; the flames are directed toward the charging end. Two barriers separate the glass in the fusing compartment from that at the place where it is taken out to be worked. The outlet is relatively small and serves only to permit the glass to be drawn off by means of a reservoir of rectangular form. The back of the latter is formed of inclined walls leaving a rather small opening. The whole forms an air-tight chamber which can be connected with flexible pipes to a vacuum pump or a compressor. For filling, the lower edges of the reservoir are immersed about 60 mm. into the glass of the tank; then, under the action of the vacuum, the glass is drawn up to fill the space left for it. The whole thing, being attached to a rolling bridge, can be brought in front of the cylinder of a casting table. The interior of the reservoir is again connected with atmospheric pressure and the glass runs out from the bottom in front of the cylinder. When the pouring is ended, a mixture of gas and air is introduced into the reservoir; it ignites and eliminates waste glass adhering to the walls. M.V.C.

Insulation of glass-furnace regenerators. J. E. Mc-

BURNEY. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; *Ceram. Ind.*, **25** [1] 18–19 (1935); *Glass Ind.*, **16** [7] 214–15 (1935).—Most of the insulation applied to the larger glass furnaces during the past few years has been confined to the regenerators, although recently several furnace caps have been insulated. The effect of insulation should show up in fuel consumption. From an analytical standpoint, the changes in temperatures in the brickwork throughout the furnace system and in waste-gas analyses are important, since, by use of this data, predictions can be made of the results anticipated on future installations. The conductivity of the insulating materials can be readily calculated on the basis of hot-plate tests. The heat loss and surface temperatures of various combinations of insulation and brickwork can then be figured for use in determining the extent of insulating from the economic viewpoint. A contact thermocouple is used to measure surface temperatures. It is important to make temperature measurements of air and waste gases when attempting to determine the effect of insulation on regenerators. An inspirating thermocouple is used for this purpose. Data obtained on an insulated glass tank are discussed. By sealing and insulating the port necks, regenerator caps, and regenerator walls, a fuel saving of 8% of the original consumption was obtained. The tight sealing of the walls to prevent infiltration of air produces the greatest return in proportion to the original cost. E.J.V.

Irregularities in the refractive index in the interior of a glass. NIUTA KLEIN. *Compt. rend.*, **200** [22] 1848–50 (1935).—By means of an interferometer it is possible to determine the irregular course of the refractive index and also to draw the lines of equal indices in the interior of a piece of glass, *e.g.*, a lens. Two examples of borosilicate crown glass illustrate the application of the method. M.H.

Meaning and measurement of the surface tension of glass. C. G. HARMAN. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 200 (1935). E.J.V.

Measurement of the viscosity of molten glass and verification of the formula of Le Chatelier. I. The falling sphere method. B. DERYAGIN AND M. VOLAROVICH. *Jour. chim. Phys.*, **31** [8] 471–88 (1934).—The viscosity, η, of molten glass was measured in an electric furnace at temperatures between 850 and 1400°. Spheres of platinum containing 15% iridium were allowed to fall through the molten glass, and the rate of fall was observed by means of X-ray photography. By applying Stokes' law, the values of η were calculated. The determinations are in accord with Le Chatelier's formula. For ten glasses, η varied between 98 and 77,000 poises and the difference $t - t_{calc.}$ was never greater than 5°, with a mean of 1.8°. **II. Concentric cylinder method.** *Ibid.*, **32** [2] 142–54 (1935).—Because of the difficulties encountered in high-temperature work a specially constructed apparatus is used for determining the viscosity of molten glass. The outer cylinder is stationary in the furnace, while the interior cylinder is moved by the aid of a constant force, *i.e.*, a falling weight. In this case the value of the viscosity is a function of weight expressed as $\eta = K_r^P$, where P represents the weight, r, the number of revolutions of the interior cylinder during a certain unit of time, and K, the constant for the apparatus, determined on calibration. This method has several advantages: owing to the rotation of the cylinder the glass is stirred up, the temperature is equalized, and the bubbles of air which might influence the results of the measurements are eliminated. Since the glass in this apparatus is between cylinders of platinum and iridium, the composition will not change. A set of determinations on the same ten glasses was made, and the difference in results obtained by the two methods corresponded on an average to a difference in temperature of 6° which indicates a sufficient accuracy of the two methods. E.J.V.

Melts of high-alumina glasses. W. S. DEBENHAM. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 200 (1935). E.J.V.

Metallizing glass by cathode spraying. A. ANDANT. *Documental. Sci.*, **3**, 100–108 (1934); abstracted in *Chem. Zentr.*, **i**, 1094 (1935).—Apparatus and procedure used and the properties and uses of films are discussed. M.V.C.

Observations on the action of steam on glass. O. G. BURCH. *Jour. Amer. Ceram. Soc.*, **18** [8] 233–38 (1935).

Optical glass history. MORITZ V. ROHR. *Nova Acta Leopoldina* [N.S.], **2**, 147–202 (1934); *Chem. Abs.*, **29**, 3123 (1935).—From the first optical glass made in Venice, *circ.* A.D. 1300, the history of these special glasses is traced to 1890. Developments in Jena are emphasized. Sixty-two references.

Permeability of glasses to ultra-violet light measured with a fluorescence screen. P. W. DANCKWORTT AND E. JÜRGENS. *Arch. Pharm.*, **272**, 713–15 (1934); abstracted in *Chem. Zentr.*, **i**, 1603 (1934).—The permeability of glasses to ultra-violet rays is easily determined by projecting a line spectrum in ultra-violet on a fluorescence screen and photographing it. An Hg-vapor lamp is used. The glasses to be tested are brought into the rays of the Hg-lamp. M.V.C.

Phenomena produced by the Corhart block upon glassware. KITSUZO FUWA. *Jour. Jap. Ceram. Assn.*, **43** [506] 63–75 (1935).—A tank furnace of the Tokio Electric Co. for soda-lime-magnesia-silica glass was repaired, American clay blocks being replaced for its side walls and bottom by Corhart blocks. The furnace produced, for a certain period, glass articles which showed fine transparent cords when they were frosted by an etching solution mainly composed of HF and acid ammonium fluoride. F. searched for the cause by putting pieces of three different blocks in the glass in pots with following results: (1) With the Corhart block, the alumina content of the glass increased intermittently, causing similar cords. X-ray pattern and n_D of the cords were the same as the adjacent glass. (2) With the clay block the alumina content of the glass increased continuously, causing cords which were not so transparent after frosting as in (1). (3) The pieces of the Corhart block were corroded evenly, whereas those of the clay block were attacked unevenly or they disintegrated. (4) The substance dissolving from the Corhart block was chiefly alumina which mixes only gradually into the glass, while that from the clay block was aluminium silicate which mixes readily with the glass. S.K.

Plate glass making. ANON. *Verre & Silicates Ind.*, 6 [11] 202–205 (1935).—The evolution of the manufacture of plate glass is traced. The gradual substitution of machines and motor power has lowered the price and improved the quality of the glass. M.V.C.

Polymerized acrylic acid ester for safety glass. HEINRICH WIESENTHAL. *Kunststoffe*, **24**, 104–105 (1934).—Polymerized acrylic acid esters, known also as Plexigum, are used for many technical purposes. Safety glass is manufactured in which Plexigum is used as a binder and center layer, the latter being flexible, colorless, odorless, and more fireproof. Safety glass made with an intermediate layer of celluloid or acetylcellulose will change with weathering. Safety glass with two layers of glass and a layer of Plexigum has proved stable under the combined action of sunlight, moisture, etc. This new safety glass, called Luglass, has excellent elasticity and greater transparency. See also *Ceram. Abs.*, **13** [1] 8 (1934). L.E.T.

Quartz ware and quartz glass (fused quartz) as building and industrial material. ANON. *Metallbörse*, **24**, 1386–87 (1934); abstracted in *Chem. Zentr.*, **i**, 1288 (1935).—A review is given of the production, properties, and uses of quartz ware and quartz glass. M.V.C.

Rate of melting. W. B. SILVERMAN. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 199–200 (1935). E.J.V.

Reciprocal action of electrodes and molten glass in electric melting. YU. A. GASTEV AND M. S. FEDOROVA. *Keram. i Steklo*, **11** [4] 19–26 (1935).—Studies showed that the most stable materials for electrodes are (*a*) alloyed steel, (*b*) soft iron, and (*c*) ordinary iron. Electrodes should be coated with chromium precipitated electrolytically. The electrodes are corroded during the last hours of glassmelting and during its refining. Air cooling, which lowers the temperature of the body of the electrode, markedly improves the quality of the glass. Decolorizing of the glass mass with selenium yielded good results. Illustrated. M.V.C.

Resistance of glasses to the attack of fluorine. E. DARMOIS AND YEU KI HENG. *Jour. phys. radium*, **5** [12] 169–70 (1934); abstracted in *Physik Ber.*, **16** [12] 1001 (1935).—The attack of F ions on ordinary and Bohemian glass, Pyrex-brand glass, Sibor, 202, and Labo was determined by rotation of the plane of polarization. The logarithm of rotation is a linear function of time. M.H.

Scratch hardness of glasses. K. C. LYON. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 200 (1935). E.J.V.

Sealing edges of safety glass. A. BRESSER. *Kunststoffe*, **24**, 231–32 (1934).—B. discusses briefly the importance of proper sealing of the edges of safety glass to protect the glass against destructive forces, especially moisture. Several of the principal German, British, American, and French patented processes are discussed. L.E.T.

Selenium decolorizing. E. J. GOODING AND J. B. MURGATROYD. *Jour. Soc. Glass Tech.*, **19** [73] 43–103 (1935).—A comprehensive and critical survey of literature on the subject is given, attention being drawn to unstudied phases of selenium decolorizing. A series of melts was made in small pots in a gas-fired furnace, and the glasses were cast into cylindrical specimens 1 in. in diameter and 1 or 2 in. long. The colors of the glasses were expressed quantitatively on the Lovibond scale, and the results obtained were used as a basis for formulating a theory of the reactions which occurred. One standard base glass was used throughout, and various additions of minor constituents were made. The composition of the base glass, which was suitable for bottles, and the additions made are given. The glasses were subjected to reheating and sunlight treatment. It is suggested that the iron occurring in glass was present as ferric oxide which decomposed with increasing temperature to ferroso-ferric oxide with the loss of oxygen. The action was irreversible unless oxidizing agents remained in the glass. Selenium reacted with the ferroso-ferric oxide, forming a ferrous selenide, while arsenic combined to yield ferrous arsenate. This compound was ionized by the action of sunlight. Sunlight, however, had no effect on selenium or selenium compounds in glass. A.A.

Striation and rate of drawing of the Fourcault ribbon. I. I. KITAIGORODSKIĬ. *Keram. i Steklo*, **11** [3] 18–19 (1935).—Details of the production of glass on Fourcault machines in Russia are given. One of the chief reasons for the appearance of striae is the unsatisfactory composition of the glass batch. M.V.C.

Tensile strength of glass. A. E. BADGER AND W. B. SILVERMAN. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 200 (1935). E.J.V.

Thermal expansion of glass. J. J. THEODORE. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 200 (1935). E.J.V.

Erratum

Testing pressure containers under sustained pressure. ANON. *Ceram. Abs.*, **14** [7] 161 (1935).—This article was incorrectly credited to F. W. Preston. EDITOR

PATENTS

Apparatus for gathering molten glass. F. G. SCHWALBE. Brit. 430,303, June 26, 1935 (Dec. 11, 1934).

Apparatus for the intermittent manufacture of laminated glass. PILKINGTON BROS., LTD. Fr. 776,004, Jan. 15, 1935; *Chem. Abs.*, **29**, 3480 (1935).

Apparatus for making reinforced glass. SCHLESISCHE SPIEGELGLAS-MANUFACTUR CARL TIELSCH, G.M.B.H. Fr. 775,710, Jan. 8, 1935; *Chem. Abs.*, **29**, 3127 (1935).

Apparatus for window glass. J. S. GREGORIUS (Pittsburgh Plate Glass Co.). U. S. 2,006,352, July 2, 1935 (June 29, 1932).

Centrifugal glassmelting furnace. JOHN FERGUSON. U. S. 2,006,947, July 2, 1935 (June 14, 1930).

Colored glass. SOC. ANON. HOLBREVER. Fr. 775,955, Jan. 14, 1935; *Chem. Abs.*, **29**, 3480 (1935).—The dye is added to the glass between its exit from the basin and the feeder or other distribution organ.

Coloring glass. GLASHÜTTENWERKE VORM. J. SCHREIBER & NEFFEN. Austrian 140,547, Feb. 11, 1935; *Chem. Abs.*, **29**, 3797 (1935).—Colored coatings or patterns are produced directly on sulfide glass not containing free C by coating the glass with a Cu compound or a com-

position containing a Cu compound and then refiring. A typical sulfide glass is made from a mixture containing sand 87, soda 20, K_2CO_3 10, CaO 11, borax 2, and FeS 3 parts. A typical coating composition contains CuO 30, calcined $CuSO_4$ 30, and calcined clay 120 parts.

Compound glass. Emil Geisel (Rohm & Haas, A.-G.). U. S. 2,007,645, July 9, 1935 (Jan. 2, 1929).

Electric lamp bulbs. Jérôme & Bonnefoy & Cie. Fr. 776,979, Feb. 8, 1935; *Chem. Abs.*, **29**, 3797 (1935).—Yellow glass for motor lamp bulbs, etc., contains CdS and S. An example contains sand 10, soda 4.5, $CaCO_3$ 1.8, ZnO 0.4, CdS 0.45, S 0.15, As 0.03, and Sb regulus 0.015 part. The bulbs are made at as low a temperature as possible and reheated. Subsequent heating may be avoided by adding Sn oxide and Se.

Etching glass. Firma Carl Zeiss. Ger. 609,468, Feb. 15, 1935; *Chem. Abs.*, **29**, 3127 (1935).—An improvement is described in the known process of etching glass in which the glass is coated with a light-sensitive layer, and the latter is exposed and developed in such a manner as to uncover the parts of the glass which are to be etched. The improvement consists in first coating the glass with a metal or metal compound insensitive to HF, *e.g.*, Pt, Au, or sulfide or selenide of Pb or Sb. After the development of the light-sensitive layer, the exposed parts of the metal or metal compound are dissolved away, and the glass is etched with HF in the usual manner. The process is particularly useful in graduating glass apparatus and in making diffraction gratings and screens for use in photomechanical printing.

Etching inside of lamp bulbs. H. L. Schlott (Kooperativa Förbundet). Swed. 79,815, March 13, 1934; *Chem. Abs.*, **29**, 3480 (1935).—The etching liquid is forced into the glass bulbs by aid of its own static pressure. Apparatus is described.

Fluoride borosilicate glass. Harrison P. Hood (Corning Glass Works). Can. 349,427, April 9, 1935; *Chem. Abs.*, **29**, 4144 (1935).—Borosilicate glass consists of SiO_2 80 to 90, Na_2O less than 5, B_2O_3 7 to 15, and F more than 0.75%, all as analytically determined. The ratio of alkali oxides to F should amount to less than 4 to 1 and the ratio of SiO_2 to B_2O_3 between 6 and 12 to 1.

Glass. Corning Glass Works. Fr. 777,440, Feb. 20, 1935; *Chem. Abs.*, **29**, 4144 (1935).—Glass compositions of the ternary system R_2O–B_2O_3–SiO_2, where R is Na, K, or Li, or more than one of these, *e.g.*, containing SiO_2 75, Na_2O 5, and B_2O_3 20%, are heated to about 525° for three days or higher for a shorter time, when the glass separates more or less completely into two distinct phases, one rich in B_2O_3 and alkali and soluble in acids and one rich in SiO_2 and insoluble. The soluble phase is separated by treatment with acids which leaves a porous glass of the approximate composition B_2O_3 5, Na_2O 0.5%, and SiO_2 the rest; this is useful as such for many purposes or it may be heated to vitrification to give a nonporous structure.

Glass articles. Libbey Glass Mfg. Co. Fr. 777,460, Feb. 21, 1935; *Chem. Abs.*, **29**, 4144 (1935).—A form is dipped into the molten glass and withdrawn with a surrounding coating of cooled glass.

Glassworking machines. British Thomson-Houston Co., Ltd. Brit. 430,716, July 3, 1935 (Jan. 27, 1934).

Grinding. Josef Desenberg. U. S. 2,005,718, June 25, 1935 (Oct. 26, 1931). The method of grinding and polishing a lens is covered.

Grinding composition. H. C. Fuchs (Permatex Co., Inc.). U. S. 2,006,162, June 25, 1935 (July 25, 1934). The paste-like grinding composition contains bentonite, water, an abrasive, and a glycolic compound.

Laminated glass. E. L. Fix and J. C. Zola (Duplate Corp.). U. S. 2,006,347, July 2, 1935 (April 11, 1933).

Laminated glass and process of making. E. L. Fix and J. C. Zola (Duplate Corp.). U. S. 2,006,348, July 2, 1935 (June 30, 1934).

Laminated safety glass. J. D. Ryan (Libbey-Owens-Ford Glass Co.). U. S. 2,006,182, June 25, 1935 (Aug. 20, 1934).

Luminescent glass. Glaswerk Gust. Fischer. Fr. 44,373, Dec. 29, 1934; *Chem. Abs.*, **29**, 3127 (1935); addition to Fr. 767,436 (*Ceram. Abs.*, **14** [7] 163 (1935)).—Oxides or selenides of Zn, Ca, Ba, or Sr are used instead of the sulfides. The same heavy metals are added.

Machine for making glass tubes, etc. Jakob Dichter. Ger. 606,728, Dec. 8, 1934; *Chem. Abs.*, **29**, 3797 (1935).

Manufacture of lenses. G. A. Clement. U. S. 2,007,366, July 9, 1935 (Dec. 7, 1933).

Manufacture of stamped glass. T. Davidson. Brit. 430,315, June 26, 1935 (March 19, 1935).

Means for supplying a polishing medium to polishing machines. J. P. Crowley (Libbey-Owens-Ford Glass Co.). U. S. 2,006,196, June 25, 1935 (March 11, 1929; May 6, 1932).

Mechanism for transferring glassware. A. W. Beeson (Hazel-Atlas Glass Co.). U. S. 2,007,592, July 9, 1935 (Feb. 7, 1934).

Method and apparatus for sealing electric lamps, etc. F. J. Malloy and R. B. Thomas (General Electric Co.). U. S. 2,006,231, June 25, 1935 (Sept. 28, 1934).

Method and apparatus for uniting bases to the glass bulbs of electric incandescent lamps, etc. Peter Herre, *et al.* (General Electric Co.). U. S. 2,008,503, July 16, 1935 (Dec. 14, 1933).

Method of forming hollow glassware. K. E. Peiler (Hartford-Empire Co.). U. S. 2,008,312, July 16, 1935 (March 25, 1933).

Method of sealing metal wires to glass. D. S. Gustin and W. D. Flook (Westinghouse Lamp Co.). U. S. 2,006,568, July 2, 1935 (July 1, 1932).

Process of electrically melting and refining glass and apparatus therefor. John Ferguson (Fairmount Glass Works, Inc.). U. S. 2,007,755, July 9, 1935 (July 1, 1933) and U. S. 2,008,495, July 16, 1935 (May 18, 1934).

Process of manufacturing lead glass. Ludwig Schertel (Th. Goldschmidt A.-G.). U. S. 2,007,349, July 9, 1935 (Sept. 9, 1932). In the manufacture of homogeneous, optically clear lead glass, a process comprises fusing on a reverberatory hearth by flame heat a mixture of lead oxide and silica in the ratio required to form a lead silicate free from uncombined lead oxide or silica, withdrawing and cooling the melt, comminuting the cooled melt, and fusing the comminuted material in a crucible at a moderate temperature until optical homogeneity is obtained, ingredients other than lead oxide and silica required in

making the complete glass being added to the lead silicate at some stage in the operation.

Reclaiming nonshatterable glasses. L. G. TUBBS. U. S. 2,006,527, July 2, 1935 (Feb. 24, 1934).

Safety glass. SOCIETÀ ITALIANA PIRELLI. Fr. 776,828, Feb. 5, 1935; *Chem. Abs.*, **29**, 3797 (1935).—The edges of safety glass containing a sheet of celluloid are protected by a varnish containing powdered metals or oxides, *e.g.*, minium or powdered Al, and drying oils and natural resins.

Safety glass. J. K. SPEICHER (Hercules Powder Co.). U. S. 2,006,416, July 2, 1935 (July 31, 1931).

Sheet-glass apparatus. WILLIAM WILDERMUTH (Libbey-Owens-Ford Glass Co.). U. S. 2,007,782, July 9, 1935 (May 1, 1933).

Sheet-glass forming apparatus. F. R. HOHMANN (Libbey-Owens-Ford Glass Co.). U. S. 2,006,167, June 25, 1935 (Aug. 25, 1934).

Sheet-glass scoring apparatus. J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 2,007,796, July 9, 1935 (Sept. 16, 1929).

Tempering plates of glass or metal. R. MEER. Brit. 430,396, July 3, 1935 (May 24, 1934).

Vitreous products. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE SAINT-GOBAIN, CHAUNY & CIREY. Fr. 44,310, Dec. 24, 1934; *Chem. Abs.*, **29**, 3127 (1935); addition to Fr. 746,004 (*Ceram. Abs.*, **13** [2] 38 (1934)).—Modified form of apparatus is described.

Structural Clay Products

Adsorption of water by clay building brick and some related properties. C. M. WATKINS AND B. BUTTERWORTH. *Trans. Ceram. Soc.* [Eng.], **33** [10] 444–78 (1934).—A bibliographical review of the subject is presented, and the relative utility of various methods of measuring adsorption in foretelling the probable weather resistance of brick is discussed. The rate of adsorption by capillarity is correlated with the degree of firing to which the brick have been submitted. R.H.H.P., JR.

Blue brick in Czechoslovakia. FELIX SINGER. *Brit. Clayworker*, **44** [518] 89–91 (1935).—S. gives the chemical composition of typical blue brick clays and discusses the effect of fluxes on the colors obtained. He describes in detail the wet and dry methods of manufacture, drying, and kilns used for firing. He gives a possible range of 12 shades in which such brick may be classified and refers to points which should be guarded against in bricklaying. R.A.H.

Brick and brickwork. SIDNEY TATCHELL. *Brit. Clayworker*, **44** [518] 82–84 (1935).—T. discusses the present competition of brick and concrete or other substitutes for brick and points out how the physicist can be of much aid to the brickmaker and the architect. R.A.H.

Correlation of laboratory tests with weathering properties of brick. I. Scope of investigation and description of ground-exposure test. B. BUTTERWORTH. *Trans. Ceram. Soc.* [Eng.], **33** [11] 495–526 (1934).—B. provides a means of grading brick according to their weather resistance, and describes the method of sampling and the layout of the "brick cemetery" at the Building Research Station. Illustrated. See also *Ceram. Abs.*, **14** [4] 93 (1935). R.H.H.P., JR.

De-airing of clay. JOHN M. WILLIS. *Trans. Ceram. Soc.* [Eng.], **34** [3] 197–202 (1935).—The characteristic faults, blistering, lamination, and cracking of the green clay product, have been largely overcome by efficient de-airing. R.H.H.P., JR.

Geological factors affecting clayworks. EDGAR MORTON. *Trans. Ceram. Soc.* [Eng.], **34** [2] 191–96 (1935); for abstract see *Ceram. Abs.*, **14** [7] 171 (1935). R.H.H.P., JR.

Heat insulation for buildings. R. J. MONTGOMERY. *Jour. Can. Ceram. Soc.*, **4**, 44–46 (1935).—M. discusses the value of heat insulation for buildings. If clay products do not insulate against heat losses they will not be used in many locations in building construction. The face of the building may still be brick because of appearance, weather resistance, or cost, but the rest of the wall will be of other materials. The insulating value of clay products is compared with that of nonmetallic mineral insulating materials. It is suggested that this field be explored by the clay industry and that the influence of the factors discussed be determined as applied to Canadian clays. A non-absorbent body with proper distribution of size and shape of air space should give a clay body equal to, if not better than, the insulating materials now on the market. Such a body might also have the property of good load-bearing or structural strength. The clay man should not form the opinion that ceramic products can not compete with organic insulating material. J.G.P.

House insulation. G. H. WARING. *Amer. Gas Jour.*, **136** [2] 33–35 (1932).—Gas heating on a large scale can be assured when proper insulation of the house is made. Practical tests have shown that fuel consumption can be reduced 50% when compared with a similar house not insulated. H.E.S.

Influence of sodium aluminate in a fireclay sewer pipe body. W. K. CARTER, GEORGE H. DUNCOMBE, E. E. HILLYER, AND R. M. KING. *Jour. Amer. Ceram. Soc.*, **18** [8] 251–58 (1935).

Manufacture of stoneware pipe and accessories with salt glaze. A. COULHON. *Rev. mat. constr. trav. pub.*, No. 307, pp. 56–60*B*; No. 308, pp. 70–72*B* (1935).—The exploitation of clay deposits is discussed. The question of the choice of clays for stoneware pipe and the proper combination of clays to assure the desired properties is dealt with. A general discussion of the machines used and ways of manufacturing the mix is also given. See also *Ceram. Abs.*, **14** [7] 168 (1935). M.V.C.

Market possibilities of reinforced clay tile floor. HENRY GIESE AND C. T. BRIDGMAN. *Brick Clay Rec.*, **86** [6] 201–202 (1935).—A floor system consisting of precast beams and floor-tile spanning between them has been developed as a low cost, fire-resistant floor, readily adaptable to dwellings and farm buildings. The cost is said to be only slightly over that of frame floors, and tests made on it have demonstrated the strength and stiffness of the floor. Illustrated. E.J.V.

"Mile-posts" in brickmaking. ALFRED B. SEARLE. *Trans. Ceram. Soc.* [Eng.], **34** [3] 219–30 (1935); for abstract see *Ceram. Abs.*, **14** [3] 70 (1935).
R.H.H.P., JR.

Mortars suitable from the standpoint of water-tightness in unit masonry. L. A. PALMER. *Jour. Amer. Ceram. Soc.*, **18** [8] 245–50 (1935).

Scumming of building brick. W. J. REES. *Claycraft*, **7**, 303 (1934); *Chem. Abs.*, **29**, 3476 (1935).

Standardized operations. ALFRED B. SEARLE. *Brit. Clayworker*, **44** [517] 56–57 (1935).—S. points out and discusses operations which need standardizing in most brick and tile works, *e.g.*, (1) feeding the clay or shale to the machines, (2) lifting the brick onto cars, (3) placing pressed brick on barrows, (4) placing brick in the kiln, and (5) firing.
R.A.H.

BOOK

History of English Brickwork. NATHANIEL LLOYD. New and abridged ed. The Publisher, London. Price 13s.
R.A.H.

PATENTS

Interlocking brick and wall produced therewith. S. F. BROOKS. U. S. 2,006,910, July 2, 1935 (Feb. 18, 1931).

Tile. L. E. SCHWALBE. U. S. 2,008,370, July 16, 1935 (May 22, 1933).

Refractories

Application of special refractories to glass furnaces. M. C. BOOZE. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 202 (1935).
E.J.V.

Applying insulation. R. S. MOORE. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 203 (1935).
E.J.V.

Assay crucibles from northern Ontario fire clay. F.V.C. HEWETT AND R. J. MONTGOMERY. *Jour. Can. Ceram. Soc.*, **4**, 39–41 (1935).—A series of assay crucibles was made and tested to determine the characteristics of the clay as to resistance to slag attack and to cracking or exposure to thermal shock. Four clays were selected for study: (1) a clay from northern Ontario (No. 169), (2) English china clay, (3) Ohio sagger bond B, and (4) Pennsylvania flint. The conclusions are as follows: (1) A charge of 125 g. slag was held at 1050°C for 35 min.; the crucibles showed strong corrosion and pitting. (2) Resistance to thermal shock was imposed by introducing clays of greater refractoriness. Grog of No. 169 clay was more effective than English china clay grog; bodies of 60 and 45% No. 169 clay showed the least cracking. (3) Resistance to corrosion was improved by the Ohio sagger clay, comparing favorably with the English product now widely used in Canada. (4) Other more refractory clays in this section could be used. (5) The English and the U. S. crucibles showed the same amount of silica and alumina. (6) The bulk specific gravity of the English and U. S. crucibles varied from 1.97 to 2.29, while that of the series tested ranged from 1.49 to 1.63. It is not proved that the lower value is undesirable.
J.G.P.

Basic refractories for steel-melting furnaces. I. A. H. B. CROSS AND W. J. REES. *Trans. Ceram. Soc.* [Eng.], **33** [10] 379–430 (1934).—(1) Mixtures of magnesite and kaolin have been studied with a view toward overcoming the thermal sensitivity, hydration tendency, and load properties of magnesite while maintaining its high refractoriness and slag resistance. Refractoriness varies considerably with change of composition; high refractory mixtures contain less than 23% and more than 44% MgO. Reactions between the constituents are more complete for a green firing temperature in the raw magnesite mixtures. (2) Extended tests on mixtures of Grecian magnesite and kaolin. The thermal expansion and the spalling tendency of magnesite are lowered by the addition of kaolin, a minimum being found for a mixture comparable to cordierite. The addition of kaolin to magnesite increases the range of plastic deformation at high temperatures under load, but seriously lowers the resistance to corrosion by basic open-hearth slag. (3) Microscopic investigation of magnesite-kaolin mixtures. The typical mineral of all mixtures is cordierite ($2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$), whose proportion for any given composition is a function of the heat treatment. **II. Dolomite-kaolin mixtures.** *Ibid.*, pp. 431–43. It was found that refractoriness is low with less than 50% dolomite in dolomite-kaolin mixtures, that 50 to 75% mixtures disintegrate after firing owing to the calcium orthosilicate inversion, and that 80 to 95% dolomite mixtures resist hydration and are good refractories.
R.H.H.P., JR.

Ceramic bauxite in French West Africa. V. Charrin. *Céram., Verrerie, Émail.*, **2** [2] 69 (1934).—White bauxite containing 72.15% Al_2O_3 and a low percentage of iron and silica has been found in the Niger valley in French West Africa.
M.V.C.

Characteristics of refractory products. MARCEL LÉPINGLE. *Ind. chim. belg.*, **6**, 91–105 (1935); *Chem. Abs.*, **29**, 3477 (1935).—Some Belgian refractories are reviewed. See also *Ceram. Abs.*, **14** [7] 165 (1935).

Chrome refractories experiments. W. E. PATTERSON AND C. C. WEEKS. *Jour. Can. Ceram. Soc.*, **4**, 31–38 (1935); for abstract see *Ceram. Abs.*, **14** [6] 141 (1935).
J.G.P.

Determination of resistance to spalling of refractory materials. E. K. KELER AND A. I. ZAKHAROV. *Ogneupory*, **2** [8] 34–41 (1934).—Two methods used to determine resistance to spalling were compared. The All-Union Standard (OST 5039) differs from the method proposed by Keler, the latter being based on considering the changes taking place in the object under the influence of temperature. For this purpose one half of the samples was subjected to the bending test and the other half heated in an electric furnace to 850° during 15 min. and then cooled in air. The loss in mechanical strength was tested. K.'s method is advantageous for masses if their relative resistance to spalling can be foreseen. It takes less time, and less power, fuel, and mass for making samples are required; no water is used, and the method permits determination of the loosening of structure of the samples through formation of cracks.
P.B. & E.S.

Determination of thermal conductivity of ceramic mate-

rials at high temperature. BERTIL STALHANE AND SVEN PYK. *Tek. Tid.*, **64**, 445-48 (1934); abstracted in *Chem. Zentr.*, **i**, 1436 (1935).—The apparatus and the measuring method are described. Measurements of various materials yielded the following average figures of thermal conductivity (λ .10^5): kieselguhr brick, Sil-O-Cel, 53; porous grog brick, 143; dense grog brick, 264. The exactness of measurements amounts to ±5%. The chief advantage of the method is its simplicity and the fact that it does not depend on the shape of the sample. M.V.C.

Determining the specific weight of silica brick. A. N. SHCHUKAREV AND B. D. TZIGLER. *Zavodskaya Lab.*, **3** [11] 1006–1007 (1934).—The method is based on the hydrostatic law. A Mohr-Westphal balance is used. The float on the right part of the beam is substituted by a small glass (half of a usual testing glass) suspended by a thin wire. It is balanced by two small weights, one of them weighing exactly 5 g. The determination is made as follows: 5 g. of a finely ground sample (passing 4900-mesh/cm.^{2} screen) are poured into the glass and the 5-g. weight is taken off. The sample is wetted with xylol and afterward immersed in xylol. The specific weight is calculated as follows: $d = \frac{5\gamma}{G - s}$, where γ = specific weight of xylol, G = weight loss of the glass with the sample when immersed, s = weight loss of the glass when immersed. The method proved to be simple, quick, and accurate and is recommended for plant laboratory use; 24 determinations daily can be made, instead of 10 to 14 as is the case with the pycnometer method. P.B. & E.S.

Difficulties in the manufacture of fire brick. C. R. F. THRELFALL. *Sands, Clays & Minerals*, **2** [3] 67–70 (1935).—The haphazard way in which brick were produced up to recent times is outlined, and the difficulties which had to be overcome to obtain a uniform product of a quality satisfying modern demands are discussed. Suitable mixing of water and clay by machinery is still an unsolved problem; firing methods, drying processes, and handling are discussed, and some of the chemical reactions in firing are explained. M.H.

Disintegration of firebrick linings in iron blast furnaces. CHAS. E. NESBITT. *Crucible*, **19**, 54 (1935); *Chem. Abs.*, **29**, 3476 (1935).—Brick made of clay free from Fe_2O_3 and Fe compounds, which on heating change to oxides, withstood the action of 90% CO at 420 to 470°. When Fe compounds were added in amounts of 0.25 to 1.5%, the results varied from a slight cracking to complete disintegration in 6 to 10 hr. Brick containing Fe fired at high temperatures resist the action of CO but can not withstand fluctuating temperatures.

Extraction processes for alumina. H. RUDERER. *Berg- und Hüttenmännisches Jahrbuch*, **82**, 98–104 (1934).—The processes of extracting and preparing alumina for Al production are as follows: (1) In the alkali process, bauxite is heated to about 600°C in rotating furnaces and mixed with soda, whereupon the reaction $Al_2O_3 + Na_2CO_3 = 2NaAlO_2 + CO_2$ takes place. The material must not be heated to melting temperature to avoid attack of the SiO_2-containing furnace lining. $NaAlO_2$ is ground and lixiviated with H_2O. The subsequent processes to produce Al are described. (2) Electrothermic processes: the Hall process, whereby bauxite mixed with coal is melted directly in an electric furnace, is the oldest but is too expensive. Serpek's method produces Al_2O_3 by way of AlN: $Al_2O_3 + 3C + N_2 = 2AlN + 3CO$; the nitride disintegrates according to $2AlN + 3H_2O = 2NH_3 + Al_2O_3$. The Haglund process uses the reaction Al_2O_3 (in bauxite) $+ 3C + 3FeS = Al_2S_3 + 3CO + 3Fe$. The processes of Pedersen and that of Kusnjepoff-Schukowsky are similar. (3) Acid processes have been developed, particularly for alumina containing much SiO_2. Several methods used in Germany and France and that of Buchner are described. M.H.

Extrapolation of metallurgical data to geology. RENÉ PERRIN. *Ann. Mines*, **6**, 135–70 (1934); *Chem. Abs.*, **29**, 709 (1935).—It has been found, contrary to previous experience, that for a basic slag acting on an acid furnace wall the composition of the slag changes unequally in a short time. This can not be attributed to physical inhibition but is due rather to chemical diffusion, which leads to homogenization. The extent of diffusion is modified by compound formation and temperature. Geological phenomena of metamorphism, crystalline and gaseous inclusions, and mineral deposition are interpreted from the standpoint of liquid-solid or solid-solid diffusion.

Firing magnesite brick. II. J. H. CHESTERS AND C. W. PARMELEE. *Trans. Ceram. Soc.* [Eng.], **34** [3] 203–18 (1935).—It is possible to obtain unfired test pieces having a bulk density greater than that of the usual fired magnesite brick by the proper control of grading and the use of high molding pressures. **III. Crystal size determination by the Laue diffraction method.** J. H. CHESTERS, G. L. CLARK, AND K. C. LYON. *Ibid.*, **34** [4] 243–49 (1935).—The average crystal sizes of a number of dead-burned magnesites, varying in origin and heat treatment, were found to be 0.06 to 0.08 mm. as determined by the Laue method and microscopic measurements. Austrian magnesite showed preferred orientation of the periclase crystals within the grains. Electrically fused magnesia showed signs of internal strain. For Part I see *Ceram. Abs.*, **13** [3] 62 (1934). R.H.H.P., JR.

German or foreign graphite? F. FRIEDRICH. *Metallbörse*, **24**, 778–79 (1934); abstracted in *Chem. Zentr.*, **i**, 1752 (1935).—The application field of graphite as crucible material, filling material, etc., is discussed. Comparative data on the properties and quality of German and foreign graphite are given. M.V.C.

Influence of additions on the properties of silica brick. I. S. KAINARSKY. *Ogneuporui*, **2** [8] 3–9 (1934).—Investigations on obtaining the tridymitizing effect in the process of firing silica brick at lower temperatures, in a shorter time, and without increasing volume led to additions of different mineralizers. Since the silica mass contains Fe_2O_3 and admixtures are irregularly distributed in it, new compounds are formed in the mass in the firing process and different fluxes are obtained. Therefore it would be advantageous to add a ready-made flux. Open-hearth furnace slag and slag from thermal sublimation of P, separately or combined with CaO, have been added. The following conclusions were made: (1) crushing test data vary considerably (from 177 to 722 kg./sq. cm.) depending on the quantity of flux and its chemical composition; (2) better results were obtained with three additions at a time, masses with one addition giving lower

crushing test data; (3) masses with high volume porosity give relatively lower crushing test data; (4) low melting temperatures of the additions aid in obtaining silica brick with lower specific weight; (5) the addition of a large quantity of phosphoric slag lowers the load-test values (1590 to 1605° instead of 1660 to 1670° with other additions). The best results were obtained with an addition of the three materials; (6) addition of open-hearth furnace slag gave poor results. See also "Effects of lime—," *Ceram. Abs.*, **14** [1] 15 (1935). P.B. & E.S.

Insulation of high-temperature furnaces. R. S. Barber. *Glass Ind.*, **16** [7] 205–206 (1935).—The advantages and economies resulting through the use of insulation on exposed surfaces of industrial furnace settings are well known. Savings on radiation losses are effected by use of insulation. Operating temperature as well as other factors affect the type, character, and thickness of insulation suitable for a particular furnace. Some desirable characteristics of insulating materials are listed. In selecting one of several insulating media, the thermal efficiency and first cost must be considered, as also the economical thickness of the insulation. Care must be taken in the use of insulation on arches and crowns of high-temperature furnaces where operating temperatures approach the fusion point of the refractories. Bulk density as it affects dead load on a crown requires careful consideration. Forms in which insulation is used are listed and discussed. Two widely used materials in the insulation of open-hearth roofs are diatomaceous earth and expanded mica. The former has a melting point of 2930°F and the latter, a softening point of approximately 2360°F. Methods of insulating tank blocks are discussed. E.J.V.

Laboratory classification of refractory clays. R. J. Montgomery. *Ontario Dept. Mines Ann. Rept.*, **42** [Part 3], 79–87 (1933).—This report is an appendix to the report "Lignite and refractory clay deposits of the Onakawana lignite field" (this issue, p. 231). It gives a description and the results of tests made on the samples of clay collected from the drill holes in the lignite field investigation. J.G.P.

Magnesia kiln lining progress report. C. H. Sonntag. *Rock Prod.*, **37** [12] 33–36 (1934).—The average life of 27 linings (all but one of 70% alumina brick) was 54 days. The first magnesia brick lining, never completely cooled during its entire life, had a continuous run of 310 days and gave a lining cost saving of $5749.80 as compared to the average cost of previous linings. The second magnesia lining was purposely heated up more rapidly than the first and was completely cooled and reheated in intermittent runs. It had reached a life of 404 days and was still good, having given 7.50 times the life of the older linings and a production 7.64 times as great. A comparison of lining costs per barrel of production, including labor and material, shows that the saving obtained with the second lining is three times its cost and it is still serviceable. The coating adhered well and no excessive slagging occurred. Illustrated. E.J.V.

Magnesium silicates. Steatite. III. Shoichiro Nagai and Kichinosuke Fukai. *Jour. Jap. Ceram. Assn.*, **43** [506] 55–63 (1935).—A study was made of the composition, molding, pressing, and firing temperature of test pieces: (1) Calcined or dead-burned magnesite was added to talc to make the molecular ratio of magnesia to silica in the raw mixtures 2:1, 3:2, and 1:1. Test pieces of the mixtures containing 5% moisture were molded with a pressure of 300 kg./sq. cm. and were fired at 1400 or 1450°C for 6 hr. The ratios 2:1 and 3:2 gave excellent results as to transverse and compressive strengths. (2) The test pieces were examined for spalling tendency. (3) Test pieces cut from a Korean talc cracked badly in lamellae on firing at 1000°C for 3 hr. **IV.** Shoichiro Nagai and Giichi Inoue. *Ibid.*, **43** [507] 133–41 (1935).—Experiments on the manufacture of steatite products are reported. (1) The chemical composition of talcs and Shuganseki of Manchukuo, serpentines of Japan and Korea, etc., are given. The composition of the Shuganseki agrees with the formula $2.9MgO{\cdot}2SiO_2{\cdot}1.9H_2O$. (2) A powdered talc was molded to small plates under varying pressures without water which were then fired to 1400°C. The higher the molding pressure, the greater was the bending strength of the fired products. (2) Small additions of $MgCl_2$ solution or B_2O_3 to talc were advantageous as to bending strength and porosity, though the products tended to disintegrate on storing. (3) The products obtained similarly from mixtures of a caustic magnesia and a Keisanhakudo (a white earth of Ishikawa province containing 91.8% of silica), in which the molecular ratio of MgO to SiO_2 was 3:4 (talc), 3:2 (serpentine), and 2:3 (meerschaum), were weak and too porous. They must be fired to a higher temperature. **V.** *Ibid.*, **43** [509] 263–65 (1935).—Test pieces of a powdered talc without water were molded under pressures of 200 to 600 kg./sq. cm. and were fired at 1400°C for 2 to 6 hr. The higher the pressure, the greater were the transverse and compressive strengths and the lower the porosity of the product. Longer heating was less effective than higher pressure. Dead-burned magnesia and quartz were mixed in the ratios of talc ($3MgO{\cdot}4SiO_2$), serpentine (3:2), and meerschaum (2:3). Test pieces were made by dry pressing with addition of 3% of boric acid and by firing at 1400°C for 6 hr. The products were highly porous and weak. The powdered talc was mixed with 3 to 5% of dead-burned magnesia, lime, or alumina, molded under a pressure of 600 kg./sq. cm. with or without addition of water, and fired at 1300°, 1400°, or 1450°C for 2 hr. Magnesia or lime caused deterioration; alumina was effective. Shuganseki ($3MgO{\cdot}2SiO_2{\cdot}2H_2O$), raw or calcined at 700°C, was molded with 5 to 20% of water or starch solution under a pressure of 600 kg./sq. cm. and the pieces were fired at 1450°C for 2 hr. The sole defect of Shuganseki was its high firing shrinkage, amounting to 16 to 19%. **VI.** *Ibid.*, **43** [510] 343–52 (1935).—Experiments were made on the linear change of the products in storing, their resistance to hydrothermal treatment, and their spalling tendencies. (1) Talc products expanded on storing in a room but not in a desiccator. (2) When steatite specimens were heated in steam of 10 atmospheres for 3 hr., those made of talc or talc and boric acid or $MgCl_2$ were disintegrated or expanded, while the specimen of talc and 3% alumina suffered no change. It is assumed that $3MgSiO_3{\cdot}SiO_2$, a eutectic of enstatite and cristobalite, is obtained by heating talc at 1400 to 1450°C and that the product rehydrates to talc, $3MgSiO_3{\cdot}H_2SiO_3$ or $3MgO{\cdot}4SiO_2{\cdot}H_2O$, in steam. (3) A spalling test is proposed, in

which small cylindrical test pieces are quickly dropped in cold water on heating at 800 to 1300°C for 30 min. and are then examined for the reduction of compressive strength; 800°C is best for a repeated spalling test. S.K.

Novaculite as a refractory material. C. W. PARMELEE. *Brick Clay Rec.*, **86** [6] 205–10 (1935).—Novaculite, a form of silica, is found as a gravel comprised of chert fragments and red clay, and also as solid beds of chert more or less white in color. It inverts to cristobalite more rapidly, more completely, and at a lower temperature than does quartzite, the inversion being made slowly to prevent shattering of grains. Illinois novaculite has a specific gravity of 2.541 to 2.639, depending on grain size, and a porosity of approximately 3%. Work on packing of particles showed that maximum density was obtained by use of 50% coarse, 25% medium, and 25% fine particles. Jaw crushing produced particles suitable for wet-pan grinding; the correct particle-size distribution was obtained in about 15 min. The rate of inversion was determined by use of a differential thermal-expansion apparatus. The rate of inversion to cristobalite decreases with increasing grain size and, with rapid inversion, there is considerable shattering of the grains, which becomes more pronounced the larger the grains. The composition of the bond affects the temperature of inversion and the rate of inversion of quartz to cristobalite. CaO, as a bond, holds the grains of silica firmly in place during firing. Tests on the effect of the temperature, time of firing, composition and amount of bond upon the mechanical strength and degree of inversion of novaculite are now under way. The problem seems to be to fire the material at a sufficiently low temperature long enough to develop a sound product. Illustrated. E.J.V.

Permeability of refractory materials to gases. ERIC PRESTON. *Jour. Soc. Glass Tech.*, **18**, 336–90 (1934).—P. reviews the subject chiefly from a theoretical point of view. Bibliography. A.A.

Permeability of refractory materials to gases. IV. Influence of firing process on the permeability to air of fireclay materials. F. H. CLEWS AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 28 (Aug., 1932); reprinted in *Trans. Ceram. Soc.* [Eng.], **33** [11] 479–94 (1934).—The permeability to air of three types of fire clay from the green to the finished state was measured and found to increase continuously up to 1200°. Vitrification up to 1400° leads to a decrease in permeability, provided the material is able to withstand, without cracking, the strains of vitrification. For Part III see *Ceram. Abs.*, **13** [8] 211–12 (1934). R.H.H.P., JR.

Principles of heat transmission and insulation of furnace walls. R. K. HURSH. Presented at Third Conference on Glass Problems, Urbana, Ill., May 31 to June 1, 1935; abstracted in *Glass Ind.*, **16** [7] 202–203 (1935). E.J.V.

Quartz sand in silica-brick manufacture. P. P. BUDNIKOFF. *Sands, Clays, & Minerals*, **2** [3] 85–88 (1935).—Silica brick produced from quartz sand is usually less stable in steel furnaces than silica brick made from other materials especially under sharply fluctuating temperatures. Silica brick made from sand crumble away rather quickly due to lack of a skeleton base of grains which fill the interstices between the separate grains of the matrix. Experiments showed that a good silica brick can be made by introducing to the mix up to 35% of sand; important factors for producing high-grade silica brick are preliminary grinding of the sand and adding molasses to the mix. The presence of CaO up to about 4% does not lower the refractoriness and reduces the specific weight which is 2.35 for 35% sand. The microstructure is described. M.H.

Refractories for coke ovens. G. E. FOXWELL. *Colliery Eng.*, **12**, 20–22 (1935); *Chem. Abs.*, **29**, 3125 (1935).

Rôle of beryllium oxide in soda-flux treatment of bauxites. A. ROMWALTER. *Roy. Hung. Palatin-Joseph Univ. Econ. Sci., Dept. Mining, Met., Sopron*, **6**, 58–59 (1934).—Eventual beryllium oxide contents in the Hungarian bauxites remain in the red slag when treated with soda fluxes so that the solution of aluminates passes through the filters free of Be. The beryllium oxide obtained in this process is fairly soluble in HCl, while the crystallized beryllium oxide prepared by calcination is insoluble. M.H.

Silica refractories in open-hearth furnaces. E. CRADDOCK AND E. M. MYERS. *Iron & Coal Trades Rev.*, **130** [3493] 231 (1935).—The properties of silica brick which make them particularly suitable for use in open-hearth furnaces are their resistance to high temperatures, spalling, and slag attack. The refractoriness is between 1710° and 1730°C. It is claimed that a brick in which unconverted quartz predominates, *i.e.*, quartz not converted to cristobalite or tridymite, has particular advantages in open-hearth roof construction. M.H.

Standards for refractory materials. COMITATO TERMOTECNICO ITALIANO. *Centro Studi Ceram.*, **2** [4] 38–42 (1935).—Further standards for refractory materials are given for the determination of (1) specific gravity, weight of unit of volume, apparent and total porosity, weight of water absorbed; (2) permanent volume variations; (3) resistance to pressure when cold; (4) resistance to deformation under load at high temperatures; (5) resistance to chemical attack; (6) resistance to sudden changes in temperature: cooling in water and in air currents; and (7) granulometric composition. For previous abstract see *Ceram. Abs.*, **14** [7] 167 (1935). M.V.C.

X-ray investigation of dispersed structures of different kinds of graphite. V. S. VESELOVSKI AND K. V. VASILIEV. *Z. Krist.*, **88**, 156–74 (1934); abstracted in *Chem. Zentr.*, **i**, 532 (1935). M.V.C.

BULLETIN

Thermo-insulation diatom brick. YA. KHANANOV. Edited by Koshurnikov. All-Union Institute of Specifications and Standards of Building Industry, Moscow, 1932. 16 pp. Price 1R 50k. The brochure deals with the definition, occurrences, marking, output, uses, export and import, raw materials and method of manufacture, properties, defects, tests, storing, and packing of diatom brick. Nothing particularly new. S. I. PERKAL

PATENTS

Alumina. TYUKUEI MORI (Kôta Nagata, inventor). Japan. 109,243, Jan. 17, 1935; *Chem. Abs.*, **29**, 3789 (1935).—Alunite is heated and extracted with hot water and the residue is heated with lime and Na_2CO_3 or NaOH

in the presence of a small amount of a chloride or alkali nitrate. The product is treated in solution above 30° with CO_2. Compact crystallized $Al(OH)_3$ is produced.

Basic refractory. D. P. Bogatzkiĭ. Russ. 34,575, Feb. 28, 1934; *Chem. Abs.*, **29**, 3128 (1935).—A refractory resistant to the action of basic slag is prepared from magnesite pressed into the desired form, *e.g.*, a crucible. The article is then heated with the basic slag which coats the walls of the article.

Chromite stone. Heinrich Koppers G.m.b.H. Ger. 606,701, Dec. 8, 1934; *Chem. Abs.*, **29**, 3804 (1935).—The stone is obtained by molding and firing a mixture consisting chiefly of crude Cr ore together with fused material containing Al_2O_3 and MgO and intermediate in composition between corundum and magnesia spinel.

Forming refractory articles. F. J. Tone (Carborundum Co.). U. S. 2,008,117, July 16, 1935 (May 6, 1930; June 3, 1931).—The process of forming a refractory article comprises forming a refractory mix containing particles of pronounced flaky character, placing the mix in a mold and jolting it so as to consolidate the mix and orient the flaky particles in a direction at right angles to the direction of jolting.

Furnace construction. R. D. De Wolf. U. S. 2,007,038, July 2, 1935 (April 11, 1935).

Glazed electric range heating unit and glaze therefor. J. D. Morgan (Doherty Research Co.). U. S. 2,007,111, July 2, 1935 (Oct. 17, 1931).—In an electric heating unit comprising a refractory work-carrying member characterized by high thermal conductivity and low electrical conductivity wherein an electric resistor element is embedded in the refractory member which element is subject to rapid deterioration upon prolonged exposure to temperatures of 2100° or above, the refractory work-carrying member composed of silicon and zircon bonded with a phosphate reaction product formed by firing the mixture with a phosphoric acid binder is combined with a glaze comprising the heat reaction products of silicon, aluminum, iron oxide, lime, potash, and boric acid, united with the member by heat fusion; the glaze has a glass-like appearance with a softening point not lower than 1550°F, and still is soft and free-flowing and thoroughly cured below 2100°F.

Process for the decomposition of siliceous aluminous minerals. Erich Wiedbrauck and Karl Büche (Th. Goldschmidt, A.-G.). U. S. 2,006,851, July 2, 1935 (Aug. 5, 1932).

Process for obtaining alumina. J. C. Séailles. U. S. 2,008,112, July 16, 1935 (July 27, 1933).

Production of refractory material and bodies. J. A. Law (Quigley Co., Inc.). Brit. 430,036, June 26, 1935 (Dec. 22, 1933).

Refractory brick. Veitscher Magnesitwerke-A.-G. Austrian 140,465, Feb. 11, 1935; *Chem. Abs.*, **29**, 3798 (1935).—A nonplastic material such as Si, Cr ore, MgO, or calcined clay is separated into grades of different granule size, and a mixture is then prepared containing 45 to 65% of material of granule size 0.5 to 7 mm., and 55 to 35% of material of granule size below 0.3 mm. The mixture is moistened, molded under high pressure without the aid of a binder, dried, and fired.

Refractory compositions. Camillo Konopicky. Austrian 141,155, March 25, 1935; *Chem. Abs.*, **29**, 4146 (1935).—A basic refractory material which has been sintered or fused, *e.g.*, sintered MgO, is mixed with a binder or flux which consists mainly of CaO and Al_2O_3 with or without Fe_2O_3, and contains only subordinate proportions of acidic components such as SiO_2. Alumina cement is a suitable binder. The mixtures may be molded and fired.

Refractory masses. Naamlooze Vennootschap Maatschappij tot Beheer en Exploitatie van Octrooien. Ger. 607,901, Jan. 11, 1935; *Chem. Abs.*, **29**, 4146 (1935).—Refractory silicate-like objects are made from fused glass containing basic constituents. The objects are formed by usual methods and the basic constituents are then dissolved out by the action of water or aqueous solutions under pressure. Thus readily fusible glass is made into tubes, cooled, and treated with water in an autoclave at 280 to 300°. A high-melting glass results.

Refractory material. Heinrich Koppers G.m.b.H. Ger. 606,801, Dec. 11, 1934; *Chem. Abs.*, **29**, 3799 (1935).—Plasticity-diminishing material such as corundum, spinel, or mullite, is treated with a small amount of clay-free inorganic or organic or mixed binding agent and with up to 3% of fine asbestos fiber, molded, and fired. Thus, fine-ground mullite is mixed with 1% of cellulose pulp waste and 2% asbestos fiber.

Refractory products. Produits réfractaires et céramiques du Nord. Fr. 776,657, Jan. 31, 1935; *Chem. Abs.*, **29**, 3799 (1935).—Materials, such as fired refractory clay, fired bauxite, quartzites, corundum, or chrome ore (80 to 90) previously ground, are mixed with an agglomerate, such as plastic clay (10 to 20) and a flux such as Na borate, salts of Pb or Ca, is added (0.5 to 3%). The mixture is worked as usual and molded.

Refractory products. Soc. anon. des produits réfractaires et céramiques du Nord. Fr. 777,303, Feb. 16, 1935; *Chem. Abs.*, **29**, 4146 (1935).—The material is submitted to compression by periodic shocks separated by intervals of rest.

Silica articles. Franz Skaupy. Ger. 611,098, March 21, 1935; *Chem. Abs.*, **29**, 4145 (1935).—Powdered quartz or silica is shaped to a coherent form in the cold, *e.g.*, by compression or by application to a support which is afterward removed. The articles are then heated until the quartz or silica granules have fused together, this being effected preferably *in vacuo* in a furnace in which the direct action of a flame on the articles is avoided.

Silica brick. Max Hollenweger. Ger. 596,380, March 4, 1935; *Chem. Abs.*, **29**, 4145 (1935).—A mixture of subdivided quartz with lime and (or) clay in such proportions that the mixture fuses at the firing temperature is passed through a sieve having 10,000 meshes per sq. cm. and then mixed with quartz of larger granule size. Preferably a small proportion of quartz which has passed through a sieve of 200 meshes per sq. cm. is added, followed by a larger proportion of coarser quartz. The mixture is then molded and fired.

Silica brick. Max Hollenweger. Ger. 604,341, March 13, 1935; *Chem. Abs.*, **29**, 4145 (1935); addition to Ger. 596,380. The CaO used in the process of Ger. 596,380, (see above) is replaced in part by another metal oxide, *e.g.*, MgO, MnO, Fe_2O_3, or K_2O, whereby the brick are made

more resistant to slags containing such oxides and metal vapors.

Testing metal oxides for use in making cast ceramic articles. SIEMENS & HALSKE A.-G. (Reinhold Reichmann, inventor). Ger. 609,345, Feb. 13, 1935; *Chem. Abs.*, **29**, 3127 (1935).—In the manufacture of ceramic articles by casting a slip prepared from calcined Al_2O_3, the best results are obtained when the Al_2O_3 is a mixture of Al_2O_3 calcined at a low temperature ("γ-Carborundum") with Al_2O_3 calcined at a high temperature ("α-Carborundum"). To determine whether a batch of Al_2O_3 is so constituted, the oxide is treated with a solution of a dye, *e.g.*, alizarin red, whereby the γ-Carborundum only is dyed. The presence of both types of oxide can then be determined by microscopic examination, or the proportion of each type may be estimated colorimetrically. Other non-plastic calcined metal oxides from which ceramic articles are obtainable by casting may be tested similarly.

Working up bauxite. EMÁNUEL M. WAGNER. Hung. 111,517, Feb. 1, 1935; *Chem. Abs.*, **29**, 3792 (1935).—Compounds of Fe, Ti, etc., in bauxite are converted to sulfides by heating with alkali or earth metal sulfides. The products are separated and worked up to aluminates and hydroxides.

Terra Cotta

Manufacture of general and domestic stoneware. N. D. WOOD. *Trans. Ceram. Soc.* [Eng.], **34** [5] 269–86 (1935); *Brit. Clayworker*, **14** [518] 92–96 (1935).—Processes in the manufacture of stoneware pipes, architectural faience, floor tile, and chemical and domestic stoneware such as preparation of the body, shaping, drying, firing, and glazing are discussed. R.H.H.P., JR.

Mural in bas-relief. ANON. *Design*, **36** [8] 2 (1935).—A large panel in plaster (stucco), used as a decoration in the Ford building at the Century of Progress, is very low relief and attains its plasticity only by means of sharp cuts on one side, opposite the light. Illustrated. E.B.H.

Practical clayworking. XX (*continued*). ANON. *Brit. Clayworker*, **44** [518] 73–74 (1935).—The cost of manufacture of the Courtrai or North of France type of roofing tile and a method of assessing the depreciation on a brick plant are discussed. See *Ceram. Abs.*, **14** [8] 188 (1935). R.A.H.

Scientific manufacture of stoneware tile. V–VIII. F. CHALAMEL. *Rev. mat. constr. trav. pub.*, No. 305, pp. 21–23*B*; No. 306, pp. 36–40*B*; No. 307, pp. 52–56*B*; No. 308, pp. 67–70*B* (1935).—The practical application of scientific information obtained by laboratory tests to the technique in plants manufacturing stoneware tile is explained. Clays should be chosen according to their physical and chemical composition. C. discusses the nature of fluxing materials and the nature and use of thinning agents and coloring materials. For Parts II–IV see *Ceram. Abs.*, **14** [7] 168 (1935). M.V.C.

PATENTS

Apparatus for manufacturing vari-colored tile. R. S. BOLTON. U. S. 2,007,961, July 16, 1935 (Nov. 11, 1933). A color-measuring and collecting apparatus for manufacturing tile comprises a base, a collector grid mounted on the base, a measuring grid, and an intermediate guide grid associated with the collector grid so that the cells of the various grids are in alignment, the aligned cells of the measuring grid being of less width than the cells of the intermediate grid to insure the material being delivered to the collector grid without engaging or adhering to the walls of the intermediate grid cells.

Method of packing and unpacking wall tile. H. S. MCELROY. U. S. 2,007,808, July 9, 1935 (Aug. 8, 1933). The method of handling tile consists in (1) packing the tile in a portable container in a manner securing free and unobstructed spaces between the individual tile, (2) subjecting the tile to water while still packed in the portable container to supply their faces and edges with the necessary moisture for successful setting by the tile setter, (3) unpacking the moisture-bearing tile from the container for setting, commencing with the tile which are then uppermost in the container, followed by unpacking in succession the tile there-below, thus enabling the excess moisture to drain from the tile as unpacking progresses.

Whiteware

Acid-resistance of a porcelain body. SEIJI KONDO AND SHOJU OTOMO. *Jour. Jap. Ceram. Assn.*, **43** [510] 337–42 (1935).—Kaolin, feldspar, quartz, and porcelain bodies, each heated at 600 to 1300°C for 2 hr., and mixtures of the raw material melted down and glassified were examined for the solubility in 20% HCl at 100°C with the following results: (1) The acid-resistance of the heated kaolin changes distinctly at those temperatures where marked changes occur in its thermal reaction, microstructure, and thermal expansion. Neither the feldspar nor the quartz undergoes any noticeable change in resistance by a previous heating. After heating the kaolin, feldspar, quartz, and bodies at 1100° or 1200°C, there are only slight differences in their solubilities. (2) An increase of the quartz dissolved in the feldspar causes almost no change in the resistance of the glasses, while the kaolin increases the resistance and refractoriness of the glass. (3) When the quartz and kaolin are dissolved in the feldspar at the same time, the resistance is raised markedly with an increase in the kaolin and is probably favored a little by an increase in the quartz. S.K.

Clay diaphragm. KOSHI SEKI. *Jour. Jap. Ceram. Assn.*, **43** [508] 197–200 (1935).—A study was made of the clay diaphragm for an electrolytic industry with the following results: (1) Generally speaking, water permeability of the clay diaphragm increases gradually with the rise of firing temperature up to about 1000°C and more rapidly at about 1100 to 1200°C, while it decreases suddenly at 1400°C. The permeability increases rapidly at firing temperatures where adequate firing shrinkage occurs. (2) The permeability increases with decreasing amount of clay and increase of grog. (3) The permeability is

greatly increased by an addition of carbon powder but is not influenced by its fineness. (4) High permeability of the diaphragm is not inevitably accompanied with low electric resistance, although highly permeable diaphragms, in general, show low resistance. (5) Satisfactory electrolytic yield is obtained only with those diaphragms whose permeability is within a certain range. S.K.

Dinnerware plant. L. P. REESE. *Ceram. Ind.*, **25** [1] 22–23 (1935).—The Scio-Ohio Pottery Co. plant was designed and laid out to produce plain white undecorated ware in the most efficient manner possible. Using a special clay body and glaze of such a formula as to blend perfectly when fired, the ware is once-fired, and the entire operation from the time the clay leaves the pug mill until the finished product is packed ready for shipping requires only 14 hr. This time will be reduced under a new set-up. Flat ware and hollow ware are twice fired, but cups are made in one firing. The equipment of the plant is described in detail. No ware is put in storage except in cartons ready for shipping. E.J.V.

Mason's ironstone china. I–II. MRS. F. G. BEARDMORE. *Trans. Ceram. Soc.* [Eng.], **34** [4] 231–42 (1935).—B. discusses Miles Mason who developed a tableware of English materials equal to the finest imported Chinese porcelain. Contributions of Miles Mason's sons to ceramic art are described. R.H.H.P., JR.

Nottingham stoneware. CLEMENT F. PITMAN. *Connoisseur*, **95** [401] 10–13 (1935).—Earthenware and the more durable stoneware met the domestic and commonplace demands of the 18th Century. Stoneware is earthenware so highly fired that it is sufficiently vitrified to become impervious to liquids and immune to acids. This ware was glazed with salt thrown through the top of the kiln when the pots were white hot; this caused the smoke problem which produced the blotchy speckled brown of Fulham ware and the deep "beer" brown of Nottingham ware, which also has a high metallic glaze laid over the texture of an orange skin. The brown in the Nottingham is due to ferruginous clay used. The Nottingham Borough records show the names of 57 local potteries during the 18th Century. The earliest known dated piece is the famous posset pot of 1700 made for the Mayor. Wasters were accurately measured vessels for use in taverns. The characteristic ornaments were (1) an iron brown slip applied before glazing, (2) free designs incised with a sharp point, (3) designs executed by punches and roulettes, (4) sprinkling of "potsherd" or shredded clay for contrast in textures, and (5) in later pieces, applied motifs. Illustrated. E.B.H.

Porcelain and glass in place of gold. Manufacture of artificial teeth. A. BERGE. *Chem.-Ztg.*, **59** [9] 93–95 (1935).—B. describes (1) large-scale manufacture of porcelain teeth, (2) porcelain for fillings and cementation of artificial teeth, and (3) individually sculptured teeth of glass or enamel. American porcelain teeth are composed of feldspar 81, aluminum silicate 4, and quartz 15%. German teeth contain feldspar 73, quartz 24.6, and marble 2.3%. Both contain small amounts of kaolin, which renders the mass opaque, and minute amounts of metallic oxides for coloration. The mass is ground to pass a screen of 6000 to 10,000 mesh/cm.^{2}, filled in bronze molds (slightly enlarged to compensate shrinkage during firing), and consolidated by pressure. The pressed teeth are then fired for 20 to 30 min. in the electric furnace at 1300 to 1350°C. Very slow cooling is essential. So-called porcelain cement consists of a mixture of zinc silicates, zinc phosphates, zinc carbonates, marble, and magnesite fired at 1000°C. This has not proved successful as filling material for cavities and has a doubtful value as cementing material for crowns, etc. Glass or enamel teeth are not manufactured on a large scale, but are sculptured individually on the plaster of Paris model. By composition, the materials used are glasses; by viscosity and workability, they are enamels. Two compositions are given: (*a*) for a firing temperature of 1250°C, SiO_2 61.76, Al_2O_3 16.44, B_2O_3 6.54, CaO 0.77, MgO 2.00, Na_2O 5.43, and K_2O 6.20%; loss in firing, 0.86%; (*b*) for a firing temperature of 950°C, SiO_2 61.17, Al_2O_3 3.00, B_2O_3 22.47, CaO 2.90, MgO 1.41, Na_2O 4.09, and K_2O 4.66%; loss in firing, 0.30%. With respect to quality and workability, these enamels could be used entirely to replace gold in dentistry. H.K.

Preventing contamination of ceramic bodies. ROBERT TWELLS. *Ceram. Ind.*, **25** [1] 30–34 (1935).—Dirt and foreign material not only cause discoloration of ware but also set up weak spots and cause rejects, due mainly to inhomogeneity of the body. Few foreign substances would be harmful if ground finely and distributed uniformly in minute quantities. After a slip has passed the lawns and magnet there is no practical way to remove objectionable particles from the body. The best cure for body contamination is primarily one of prevention. Cleaning raw materials as they are received, order and cleanliness in the plant, and the use of improved equipment wherever possible are listed as preventive measures. Causes and means of avoiding foreign particles in the body are tabulated. A carefully trained personnel is also helpful. E.J.V.

Whiteware materials discovered in Korea. SHINICHIRO OGAWA AND KOJI TERAZAKI. *Jour. Jap. Ceram. Assn.*, **43** [505] 2–5 (1935).—Tests have been made on three whiteware materials recently discovered in Korea: (1) Kosei kaolin produced in Koseigun, Heiannando. Residue on 200-mesh sieve is 54%. Washed kaolin is insufficient in plasticity; it contains only 0.06% of ferric oxide and a noticeable amount of pyrophyllite. The P.C.E. is cone 35. (2) Daido pottery stone produced in Daidogun, Heiannando. The ground product is less plastic than the kaolin; it contains 0.51% ferric oxide. The P.C.E. is cone 20. It is a decomposed liparite consisting of 35% feldspar, 20% clay, and 45% quartz. (3) Kosei stone produced in Koseigun, Heiannando. The ground product is poor in plasticity; it contains 0.18% of ferric oxide. The P.C.E. is cone 9. It is a decomposed pegmatite with albite, consisting of 76% feldspar, 3% clay, and 21% quartz. Satisfactory results have been obtained with bodies consisting of 55 to 80% Daido pottery stone, 0 to 5% Kosei kaolin, 0 to 2% Kosei stone, and 20% Tokiguchi plastic kaolin for Japanese porcelain ware and with bodies consisting of 45 to 60% Daido pottery stone, 10 to 15% Kosei kaolin, 10 to 20% Kosei stone, and 20% Tokiguchi plastic kaolin for European porcelain ware. S.K.

BOOK

Dresden China. W. B. HONEY. 210 pp., 61 plates

illustrating 175 pieces. A. & C. Black, Ltd., London; Macmillan Co., New York, 1934. Price $5.00. In his preface, H. states, "This book is intended to serve as an introduction to the study of Meissen porcelain of the 18th Century.....A word is perhaps needed to explain the title adopted. 'Dresden China' was the pleasant-sounding but inaccurate name given in the 18th Century to the porcelain made at Meissen, some dozen miles distant from the Saxon capital, and it is still in familiar use....The French too have avoided the name by calling the ware 'porcelaine de Saxe,' and the Italians and Spanish use a similar designation, so that we are not alone in having our own word for the china, which only a tiresome pedantry would wish to banish in favor of the more accurate name of Meissen."

H. briefly discusses oriental interests and activities in connection with the development of porcelain, its exportation to Europe, the early European researches, and the resulting styles and products. Following this survey there is an account of the work of Tschirnhausen and Böttger. Tschirnhausen's amibition to make porcelain in Saxony, his intensive investigations as to the physical properties of Chinese porcelain, his activities in promoting research and development, and his meeting with and subsequent use of Böttger may be taken as his contribution to the development while, according to H., it required "the energetic, observant, and resourceful Böttger" to make practical use of Tschirnhausen's ideas and findings.

A most comprehensive and exciting description is given of the development from the time of the formal establishment of the manufacture in 1710. Historical facts, chemists, artists and craftsmen connected with the organization, and the resulting ware are so clearly and concisely described that it is a rare pleasure to open the book at any page.

The illustrations represent typical examples rather than rarities, oddities, and so-called "important" pieces. While figurines, statuettes, and other ornamental subjects predominate, tableware is adequately represented; consequently this book contains valuable information for the American tableware manufacturer.

The book is a notable contribution to ceramic literature because however well versed in ceramic lore, the interested amateur or professional will learn and retain a fund of valuable and practical information which could not be acquired through any other source. F. H. RHEAD

PATENTS

Apparatus for molding insulators. E. H. FISCHER (Westinghouse Electric & Mfg. Co.). U. S. 2,007,567, July 9, 1935 (Nov. 21, 1934).

High-tension insulator. C. L. STROUP (Jeffery Dewitt Insulator Co.). U. S. 2,008,341, July 16, 1935 (May 26, 1933).

Insulator. E. H. FISCHER. U. S. 2,008,414, July 16, 1935 (Dec. 4, 1931). C. L. STROUP (Jeffery Dewitt Insulator Co.). U. S. 2,008,342, July 16, 1935 (Aug. 14, 1931; Dec. 7, 1934).

Method of producing lugged pottery. G. B. ZAHNISER, JR., AND J. M. SMITH, JR. U. S. 2,007,993, July 16, 1935 (Sept. 14, 1934).

Equipment and Apparatus

Crushing and grinding appliances. B. W. HOLMAN. *Inst. Chem. Engrs.* (Advance copy), 10 pp. (Oct., 1934); *Iron & Coal Trades Rev.*, **129** [3476] 535 (1934).—The various designs of crushers and characteristics and principles of crushing are discussed. M.H.

De-airing in Canada. H. F. DINGLEDINE. *Jour. Can. Ceram. Soc.*, **4**, 26–27 (1935).—D. summarizes the results observed on the application of de-airing to a fine-grain surface clay, low in lime and magnesia, which fires to a dense red body at cone 01. This clay has a very high shrinkage. The heat range is short. The material laminates very badly. The outstanding beneficial effects of de-airing this clay are as follows: (1) The fairly plastic clay is made very tough which facilitates handling without damage in the green state. (2) Somewhat less pugging is required and is even desirable. (3) All blistering is eliminated at 24 to 25 in. of vacuum. (4) Dies run better and show evidence of slighter wear on friction surfaces. (5) Ware is smoother and body structure greatly improved. (6) The effect of lamination in the fired ware is noticeably decreased at 23 in. and completely disappears at 26 in. of vacuum. (7) Absorption is decreased about 2%. (8) Crushing strength is increased about 20%. Disadvantages are as follows: (*a*) Power costs have been somewhat increased, but, with better designed dies and de-airing equipment, D. believes a slight power saving is indicated except in the case of the sewer-pipe press, where, if it is not possible to substitute a pug mill for the usual wet-pan tempering, a slight power consumption increase is inevitable. (*b*) Finished ware chips more easily, as the finer texture results in a more glassy body, the complete annealing of which would be difficult in periodic kilns and rather costly due to loss of kiln space under slow cooling. (*c*) Production speed in small sizes of sewer pipe is decreased as these sizes, usually broken off at the die, must be cut, owing to the toughness of the de-aired clay. J.G.P.

Gas-fired rotary driers. J. L. VANCE. *Amer. Gas Jour.*, **136** [3] 29–30 (1932).—V. describes a rotary gas-fired drier that has been successfully used in drying and dehydrating bulk products such as seaweed, bark, beet pulp, tankage, carbon sludge, sand, limes, ores, sugar refuse, and a special filtering clay. H.E.S.

Grinding in ball mills and tube mills. HOWARD R. STARKE. *Rock Prod.*, **38** [8] 40–46 (1935).—S. studied the following variables, using four grinding mills of varied sizes and types for grinding Portland cement clinker: (*a*) length of grinding period, (*b*) size of grinding balls, and (*c*) initial size of particles to be ground. Within the conditions of these tests on a commercial and semicommercial basis, the following generalizations may be stated: (1) During early periods of grinding in batch mills the specific surface of the charge increases nearly in proportion to time, but during later periods the rate of increase tends to diminish. (2) Mill efficiency is influenced by variation in the rate at which material is fed to a continuous discharge mill. (3) A mill is most efficient in producing sur-

face from the material used in these tests when the ratio $\left(\frac{\text{initial particle diameter}}{(\text{ball diameter})^2}\right)$ (in microns) is about 600×10^{-9}. (The optimum value of this ratio depends upon the physical characteristics of the material to be ground.) (4) Products of grinds at low ratios have appreciable weights of all particle sizes smaller than the charged size, while those of grinds at high ratios have a small weight of particles between $^1/_{10}$ and $^1/_2$ the charged size. (5) By scalping the product at commercially feasible particle sizes, high grinding ratios usually yield products of highest specific surface. (6) Materials of equal specific surface will generally have particle-size distributions more nearly alike when produced at equal grinding ratios. E.J.V.

Improvements in the MacMichael viscometer. J. BALME. *Rev. gén. mat. plastiques*, **10**, 336–37 (1934); *Chem. Abs.*, **29**, 646 (1935).—The construction and operation of the latest type of MacMichael viscometer is described.

Industrial crushing problems. J. MARY. *Usine*, **44** [14] 35 (1935).—The problems of crushing in ore dressing are discussed, and a relation is developed between volume of mass to be crushed and surfaces at the beginning and at the end of the crushing process. For unity of mass, the difference between the sum of the surfaces at the end and the sum of the surfaces at the start is a constant. Types of crushing apparatus, particularly of French make, are reviewed and their characteristics briefly described. M.H.

Lubricating dies by direct electric current. CHAS. E. BATES. *Jour. Can. Ceram. Soc.*, **4**, 22–25 (1935).—B. gives an account of the experimental work in developing a method of lubricating dies by the application of direct electric current at the die. It had previously been thought possible to secure lubrication by passing a direct electric current through the clay column, it being known that when a direct electric current is passed through any material containing moisture, the moisture collects at the negative pole or connection. A number of experiments was required before a satisfactory design of die and method of applying electric current were attained. It was found best to operate with the lowest possible voltage that gave satisfactory die operation. With lower voltage the danger of any short circuits with consequent burning of die parts was reduced. The tonnage run on the electric lubricated dies as compared with dies without electric lubrication was increased but was no greater than could be secured with other lubrication. J.G.P.

Maintaining ore flow through bins. L. DOUGLAS ANDERSON. *Eng. Mining Jour.*, **136** [5] 223–26 (1935).—Maximum capacity is given with a flat-bottomed bin of cubic shape. If, however, the bin is to be self-discharging, sloping floors must be used. If sloping bottoms are placed on two sides with discharge openings at the center where they meet, the bin should be self-emptying. If the outlet must be at the side so only one slope can be used, usually an angle of 45° will move the ore. Although angles up to 55° may be used to move very sticky ores, such angles may pinch the ore against the side wall at the discharge openings. In such cases, hoppering the bottom on each side of the openings will keep the ore moving. In flat-bottomed bins where ore forms its own slope, difficulties in discharge can be lessened by extending the smooth chute-liner run into the bin 2 to 4 ft. Ore flow through openings in vertical bin sides can be facilitated by moving the discharge gate 3 to 4 ft. down the chutes. To save wear and power in the operation of feeders from bins, the feeders should be placed so that the ore flows on them to avoid their carrying the weights of high columns of ore. For ores which do not flow well, feeders have to pull the ore by supporting the weight of a considerable column of it. Sticky ores may require heavy apron feeders extending under the full width of the bin. For ore depths to 10 or 12 ft., canvas or rubber belts on cylindrical rolls under the bin will pull the ore from the bins. An upward inclination of belt or feeder will act to agitate and move material in the bin. In cylindrical bins with conical bottoms, the slope must be greater than for flat surfaces, at least 55° for ore requiring a 45° flat surface. An effective discharge for conical bins is made with a slotted opening in the cone covered by flat plates with the discharge point under the outside edge of the bin. For ores of a sticky nature, louvers should be provided through which the ore may be barred down when it jams. Louver constructions in sloping bottoms prevent ore from sticking to an otherwise air-tight bottom. Horizontal revolving plate feeders may be designed to afford good access to the interior. An old design using a separate hopper for the feeder is being revived for flotation concentrates difficult to handle. A type of bin with a covered central tunnel through which cars may be run for unloading is described. Rough planks provide good bottoms for moving wet, slimy ores. Smooth steel plates are desirable for lumpy ores. Liner plates should have vertical joints covered by a butt strap to minimize wear and obviate curling at the corners. Covered bins and bins placed below the ground level help to keep the ore from freezing in winter. Ore difficult to handle from bins may be stored in piles under railroad trestles or in triangular section piles. A light roof is desirable for protection against rain. Various typs of machines for reclaiming ore from such piles are described. Minimum dimensions of openings through which ore is to flow should be three times the size of sized ore or twice the largest size when mixed coarse and fines are present. Compressed air can be used to bring down ore which hangs up, while compressed air pipes inside bins keep slimy ore moving. Steam can be used to thaw frozen ore quickly if the lances or pipes are properly distributed. A magnetic vibrator attached to the bin helps to keep ore from binding or sticking. Internal paddles or agitators are not generally suitable for this purpose. Illustrated. J.L.G.

Manganese steel in crushing machines. W. B. PICKERING. *Sands, Clays, & Minerals*, **2** [3] 73–80 (1935).—The superiority of Mn steel is due to the "work hardening" on its face under the effect of a rolling, crushing, or hammering action, while the inherent toughness of the material is retained in the body. M.H.

Mounting concentrates and tailings for microscopic study. PAUL H. BIRD. *Eng. Mining Jour.*, **136** [5] 233–34 (1935).—A technique for making thin sections and polished surfaces and for mounting powders for microscopic determinations is described. Bakelite resinoid BR-0014 is used as the mounting media. As used from alcohol

solution, it is cured in two stages. Heating at 75° drives off the alcohol and converts the resin to partly hardened material (when cool). The second stage of curing may be carried out in the range from 90 to 125°C. A blank $^1/_4$ in. thick requires 24 to 30 hr. at 90 to 100°C for curing. The index of refraction of the resinoid is approximately 1.63. In thin sections it is slightly yellowish in color. Illustrated by photomicrographs. J.L.G.

Nonmetallic thermocouples for highest temperatures. GEO. KEINATH. *Arch. Tech. Mess.*, **4** [48] 55*T* (1935).—K. describes the construction and properties of a carbon-nickel couple for temperatures up to 1200°C (life 130 to 320 hr.), a constantan-silicon carbide couple, a tantalum carbide-carbon couple (Ger. 593,022, Feb. 20, 1934), and a carbon-silicon carbide couple for temperatures up to 1800°C. The high thermoforce is an advantage, while the high electric resistance is a disadvantage. M.H.

Performance of a hollow-ware extrusion machine with different combinations of augers, spacers, and dies. PAUL V. JOHNSON AND RAY T. STULL. *Jour. Research Nat. Bur. Stand.*, **14** [6] 711–22 (1935); R.P. 798. Price 5¢.—A study was made of the effect of various combinations of augers, spacers, and dies on the performance of a union-type auger machine used in forming hollow clay tile. Various combinations of equipment were used consisting of augers of single-, double-, and triple-wing types, 10-, 15-, and 20-inch spacers, dies 4, 5, and 6 in. long, and die tapers of 0, 2, 3, 4, and 6°. Measurements were made of the rate of extrusion per units of time, power input, and power absorbed by the auger. Density determinations of the clay column extruded were also made. From the data obtained, the following conclusions seem justified: (1) The single-wing auger is most efficient as to rate of extrusion and power consumption but can not be used throughout as wide a range of variable conditions of spacers and dies as can the double- or triple-wing augers. (2) The greater the spacer length, the greater is the power consumption and the lower the rate of extrusion. (3) Power consumption increases as the die length is increased. Within practical working limits, changes in die length have no appreciable effect on rate of extrusion. (4) Maximum rate of extrusion per minute, per horse power-hour input, and per horse power-minute consumed by the auger was obtained with a die of 3° taper. (5) Changes in die, auger, or spacer design do not materially affect the density of the extruded clay column but water content does. R.A.H.

Power used in crushing. JOHN S. OWENS. *Bull. Inst. Mining Met.*, No. 366, 39 pp. (1935); *Chem. Abs.*, **29**, 3950 (1935).—Data are given for drop-weight crushing of pyrite and quartzite. The best of several formulas developed and tested is $W = C((1/S) - (1/D))$, where W = watt-hr./ton, D = original diameter of particle, S = distance between hammer and anvil (diameter of particle after crushing), and C = constant for each ore. The limits to crushing in one operation are discussed mathematically. When crushing an isolated piece of ore, the limiting value of S is $D/7.84$; for a group of pieces the limiting value is $D/1.7$. In rolls, a high peripheral speed with a thin stream of feed gives more efficient crushing than a low speed and a thick stream. Jaw crushers and cone crushers, that carry out the process in a number of small stages with intervals when small fragments may escape, are likely to be more efficient in energy consumption than rolling.

Rotospray magnetic separator. PAUL L. REDLICH. *Enamelist*, **12** [9] 18–20 (1935).—In the new type magnetic separator, the factors of field strength, control of flow of enamel, and close proximity to the magnetic field have helped solve the problem of extraction of finely divided iron particles from enamel slip. The stream of enamel is broken up into 16 fine streams, first coming into contact with the outer edge of the 16 bar magnets where the velocity is slowest. At the outlet the opening through which the enamel must flow is less than $^1/_8$ in., with a strong magnetic field. Illustrated. E.J.V.

Temperature measurement with photocells. H. J. ZETZMANN. *Arch. Tech. Mess.*, **4**, 116–17*T* (1934).—Temperature changes which take less than 0.1 second can be correctly measured and recorded only with photocells as pyrometers; bolometers and other temperature-measuring devices have too great mechanical and thermal inertia. The principles and characteristics of a photocell are explained, and the different methods of application are described. M.H.

Vibrating screen practice. J. G. TURNEY. *Trans. Ceram. Soc.* [Eng.], **34** [4] 250–67 (1935).—The main principles of the design and operation of vibrating screens, making possible efficiencies as high as 98%, are presented. Feeding, stratification, inclination, intensity of vibration, and cloth design are discussed. R.H.H.P., JR.

Viscometric measurements of clay suspensions. G. D. HOBSON. *Jour. Inst. Petroleum Tech.*, **21**, 204–20 (1935); *Chem. Abs.*, **29**, 3897 (1935).—The viscometers used by previous workers and experiments with a new instrument are described. The latter consists of a glass bulb holding a little more than 40 cc. between etched marks, with a capillary held in position at the bottom of the bulb by means of a piece of pressure tubing. The outer glass container is a 10-in. gas jar, the capillary being kept along the axis of the jar by 4 radial wire guides attached to the piece of pressure tubing. The whole is placed in a water bath, the temperature of which can be maintained constant to within less than 0.1°. Values obtained are a function of the capillary used whether the data are interpreted as equivalent viscosities or as mobilities from the flow curves.

PATENTS

Apparatus for measuring gas temperatures. C. E. LUCKE. U. S. 2,006,469, July 2, 1935 (April 17, 1934).

Apparatus for proportioning ingredients. C. J. MORONEY AND W. O. WITHERSPOON. U. S. 2,005,950, June 25, 1935 (May 1, 1933).

Machines for the manufacture of tile, slabs, etc. H. E. DUNN AND W. E. DUNN MFG. CO. Brit. 430,555, July 3, 1935 (Sept. 5, 1934).

Method and apparatus for molding clay bodies. DAVIS BROWN. U. S. 2,005,886, June 25, 1935 (Jan. 18, 1932).

Molding presses for the production of compact molded bodies from ceramic masses, concrete, etc. E. LUX AND J. DANIELS. Brit. 429,144, June 6, 1935 (Aug. 31, 1933).

Kilns, Furnaces, Fuels, and Combustion

Bases for thermochemical calculations. W. Swietoslawski and L. Keffler. *Rev. ing. ind.* [Madrid], **5**, 389–95 (1934); *Chem. Abs.*, **29**, 2831 (1935).—A report of the Permanent Commission of Thermochemistry on the determination of the heat of combustion of solids or liquids that contain the elements C, H, O, and N is given.

Colloidal fuel. D. Brownlie. *Iron & Coal Trades Rev.*, **129** [3479] 671–72 (1934).—"Colloidal" fuel can be defined as a mixture of finely pulverized coal or other solid fuel and a liquid fuel such as oil, tar, etc., in such a condition that the solid particles will not separate out by gravity for a long period. About 30 to 50% by weight of solid fuel is generally used. The various principles and processes of making colloid fuels are reviewed. M.H.

Combustion of natural gas in glass furnaces. J. E. McBurney. *Ceram. Ind.*, **24** [4] 217–18 (1935).—The main constituent of natural gas is methane, varying between 80 and 90%. The heating value is 950 to 1200 Btu/cu. ft. on a gross basis, 10% less on a net basis. The higher the hydrogen content, the greater is the difference between net and gross. Natural gas is generally introduced through the sides of the ports at such an angle that the two gas streams will meet just inside the combustion chamber. Pressure and velocity vary, depending upon the type of gas and particularly the methane content, since methane retards the rate of flame propagation. Improper velocities give less luminous flame, resulting in greater fuel requirements. Velocities must be determined by experiment. Gas with a high methane content might require a $1^1/_2$-in. burner tip; with low methane content, it might be satisfactorily burned through a $^3/_4$-in. tip. Full luminosity is obtained by introducing air and gas into the combustion chamber separately and at the same velocities. This will cause the gas to burn slowly at the flame front, mixing occurring principally by diffusion. E.J.V.

Control of atmosphere in kilns. M. H. Mawhinney. *Bull. Amer. Ceram. Soc.*, **14** [7] 222–24 (1935).

Design of main flues and stacks for continuous ceramic kilns. S. R. Hind. *Bull. Brit. Refrac. Research Assn.*, No. 26 (Aug., 1931); reprinted in *Trans. Ceram. Soc.* [Eng.], **33** [12] 549–59 (1934).—The modern theory of gas-flow is applied to the design of main flues and stacks as well as to the arrangement of dampers in ceramic kilns together with a consideration of the frictional losses. R.H.H.P., Jr.

Determination of gas, coke, and by-products of coal. Evaluation of laboratory assay tests. W. A. Selvig and W. H. Ode. *Ind. Eng. Chem., Anal. Ed.*, **7** [2] 88–93 (1935).—Two small-scale, laboratory, high-temperature assay tests and one low-temperature assay test for the determination of yields of gas, coke, and by-products of coal were applied to 20 to 30 coals. Check limits were established on the same coal by the same laboratory. Yields of gas, coke, and by-products by the laboratory tests were correlated with yields obtained by the Bureau of Mines-American Gas Assn. carbonization test. The factors for converting the yields obtained by the small-scale laboratory tests into those obtained by the Bureau of Mines-American Gas Assn. carbonization test vary appreciably with different coals. F.G.H.

Determining the correct weight of sample in coal sampling. L. S. Kassel. *Ind. Eng. Chem., Anal. Ed.*, **7** [2] 112–15 (1935).—A mathematical treatment of the theory of coal sampling for float-and-sink determinations is developed, and the results are shown to agree well with practical sampling tests. The theory of sampling for ash analysis is sketched; this is a more complex problem and the theory can not be applied without extensive tests, so that its use is limited to the large producers. The use of duplicate samples to determine sampling errors is illustrated. The gross error of sampling and analysis is frequently greater than the lot-to-lot variation in coal from the same source. Illustrated. F.G.H.

Direct simultaneous microdetermination of carbon, hydrogen, and oxygen in organic substances. I. Analysis of pure compounds containing carbon, hydrogen, and oxygen, with and without halogens. W. R. Kirner. *Ind. Eng. Chem., Anal. Ed.*, **6** [5] 358–63 (1934).—A direct simultaneous micromethod has been developed for the determination of carbon, hydrogen, and oxygen in compounds containing these elements alone or with chlorine and bromine also present. The investigation is being continued on more complex compounds and will be extended to the analysis of coal and its products. Illustrated. F.G.H.

Electric furnaces for ceramic firing. E. J. Harris and B. A. Bovée. *Bull. Amer. Ceram. Soc.*, **14** [7] 219–22 (1935).

Equipment for smoke prevention and complete combustion in pottery kiln. Hachijiro Matsumura. *Jour. Jap. Ceram. Assn.*, **43** [509] 287–94 (1935).—An equipment for smoke prevention and complete combustion of coal-fired periodic kilns was invented by M. (Japan. Pat. 110,057). M. succeeded in reducing the smoke from a porcelain kiln in the reducing period. He also achieved an increase of output over 59%, a reduction of coal of 10 to 17%, and a saving in time, *e.g.*, 31 hr. against 35 to 36 hr. in biscuit firing and 16 to 19 hr. against 22 to 23 hr. in glost firing of hard faience. Each fire box has a coal-feeding opening on its top wall. The lower end of the opening is bent toward the back part of the fire box. Several longitudinal ridges are furnished on the inner sides of the opening. A funnel-shaped hopper with an elastic valve inside is built on the opening. Definite amounts of coal are fed into the hopper intermittently and mechanically. S.K.

Fuel-fired and electric tunnel kilns in the ceramic industry. Philip Dressler. *Jour. Can. Ceram. Soc.*, **4**, 20–21 (1935).—The most important factors to be considered when contemplating the installation of a tunnel kiln are (1) the size and production of the kiln (it must not be so large that it can not be kept running at full capacity and must not be too small for economical production), (2) the fuels available and their relative present and future costs, and (3) the type of kiln which will fire the ware most economically. The types of kilns available for use in the ceramic industry are (*a*) electric, (*b*) fuel-fired full muffle,

(*c*) fuel-fired direct fired, (*d*) fuel-fired semidirect fired, and (2) fuel-fired conveyer-type kilns. J.G.P.

Gas analysis by means of a micro-heat conducting apparatus. PH. GROSS AND H. STEINER. *Mikrochemie*, **11**, 43–46 (1935).—The composition of gas mixtures may be determined by measuring their heat conductivity. The authors have developed a micro-heat conducting cell in which a wire is electrically heated in an atmosphere of the gas to be analyzed. An illustrated description and methods of calculating the heat consumed by the gases are given. L.E.T.

Gum deposits in gas-distribution systems. Vapor-phase gum. C. W. JORDAN, A. L. WARD AND W. H. FULWEILER. *Ind. Eng. Chem.*, **26** [9] 947–55 (1934).—Gas particles are formed and remain dispersed in gas containing any of a large number of organic compounds and nitrogen peroxide or nitric oxide and oxygen. Many types of manufactured gas contain a sufficient quantity of oxides of nitrogen to form this type of gum, here designated as vapor-phase gum. If present, this material will cause stoppage of ordinary pilot lights and the malfunctioning of automatic gas devices such as water heaters. It may also give trouble in gas-handling apparatus in the plant. The gum contains about 5% nitrogen and 20% or more oxygen. Its formation involves not only oxidation but probably adsorption, condensation, or polymerization, in addition to the primary reaction between the carbon compound and the oxide of nitrogen. About 80% of the gum particles are electrically charged. When first formed they are probably of molecular size. They coalesce until, at a size of approximately 0.1μ, they become visible in the ultramicroscope with arc-lamp illumination. The coalescence continues until a size of 1 to 1.5μ is reached, after which they can no longer remain dispersed in the gas. In manufactured gas, which always contains oxygen, the presence of nitric oxide to the extent of a few tenths milligram per cubic meter, or a concentration by volume of a few parts in ten million, will cause the formation of particles, the number of which reaches the order of 10^{12}/cu. m. Illustrated. F.G.H.

Industrial furnaces for gas. L. E. BIEMILLER. *Amer. Gas Jour.*, **138** [1] 16–18 (1933).—Kilns, using gas as a fuel in the heavy clay products industry, *viz.*, the scove, downdraft beehive, chamber, and tunnel, are described. The advantages of gas as a fuel are increased saving in labor, higher percentage of first-quality product, better color, less firing time required, more uniform firing, and ease and cleanliness of operation. H.E.S.

Industrial gas men inspect pottery kiln. H. M. RILEY. *Amer. Gas Jour.*, **140** [2] 35–37 (1934).—The indirect heating of fine glazed ware in muffles, saggers, etc., is expensive. A rather high Btu input per unit of ware is obtained, and little opportunity to utilize the form value of refined fuels is made. Maintenance costs on such equipment are also high. High-grade glazes can be fired with convected heat in controlled complex atmospheres consisting of products of combustion, excess oxygen, and vaporized glaze. This form of firing is adaptable to natural gas by simple changes in the burner design. Laboratory tests and tests on kilns at industrial plants were made. H.E.S.

Microanalysis of gases. III. Hydrogen, carbon monoxide, hydrogen chloride, and ammonia. F. E. BLACET AND G. D. MACDONALD. *Ind. Eng. Chem., Anal. Ed.*, **6** [5] 334–36 (1934); for Part II see *Ceram. Abs.*, **13** [1] 24 (1934). F.G.H.

Observations on setting. II. L. R. WHITAKER. *Brick Clay Rec.*, **86** [6] 203–204 (1935).—Types of settings are described and discussed from the standpoint of percentage of open space. The effects of setting excessively open or close are listed. For Part I see *Ceram. Abs.*, **14** [7] 164 (1935). E.J.V.

Oxidation of ceramic ware during firing. VII. Review. FREDERICK G. JACKSON. *Bull. Amer. Ceram. Soc.*, **14** [7] 225–29 (1935).

Principles of recuperation applied to industrial gas furnaces. E. A. LUSCOMBE. *Amer. Gas Jour.*, **137** [6] 9–12 (1932).—New economies in industrial procedures are constantly sought. Such economies can be extended with industrial gas furnaces by the application of the principles of recuperation. Heat introduced by preheated air may be utilized to increase the quantity of useful work, to increase furnace temperature, or decrease the volume of gas burned. The formulas presented for calculating gas savings resulting from burning gas with preheated air are valid for neutral, reducing, and oxidizing atmospheres. A temperature of 1000°F is recommended as the maximum safe air temperature to be used with premixing burners. Heat- and corrosion-resisting materials are recommended for the construction of recuperator elements, air lines, and burner tips. Air temperatures should not be in excess of 60% of the flue-gas temperature. H.E.S.

Propane and butane as industrial fuels. E. A. JAMISON AND W. H. BATEMAN. *Iron & Steel Engr.*, **12** [4] 209–14 (1935).—An outstanding development in modern fuels and methods of firing has been the advent of the liquefied petroleum gases, propane (C_3H_8) and butane (C_4H_{10}), as industrial fuels. These gases are pure hydrocarbons. Both are readily condensible under proper conditions of temperature and pressure, the major differences between them being in boiling point, vapor pressure, and Btu/gal. The ratio of production and consumption is about 25:1. The average properties of the two liquefied petroleum gas products are tabulated. Methods of using these gases as fuels, *i.e.*, combustion systems suitable to their use, are described. The following advantages of liquefied petroleum gases over fuel oil are listed: (1) no pumping required, (2) no steaming of tank car required for unloading, (3) no sediment or sludge as waste material, (4) sulfur fumes eliminated, (5) no grease or dirt inside of buildings, (6) no smoke or soot when starting up furnaces, (7) reduced maintenance on furnace refractories and alloy parts, (8) no sulfurization of alloy furnace parts, (9) improved furnace control as to temperature and atmosphere, and (10) reduction in scaling of product. See also *Ceram. Abs.*, **14** [8] 198 (1935). E.J.V.

Propane total-heat curve. E. G. RAGATZ. *Petroleum World*, **31** [12] 43–44 (1934); *Chem. Abs.*, **29**, 1694 (1935).—A C_3H_8 chart, calculated on the basis of existing data, agrees closely with Lacey's experimentally determined curve. Questions are propounded on the basic data and the practical utilization of the chart.

Refractory screen oil tests in Denver. G. WEHRLE. *Amer. Gas Jour.*, **139** [2] 7–9 (1933).—To provide a sub-

stitute for natural gas in cases of emergency in Denver, two water-gas sets were converted to the refractory screen oil-gas process. The process is similar to water-gas operation with the coke bed replaced by a bed of refractory material. The refractory screen cracks the oil sprayed into the top of the generator. The process appears to be practical for emergency and standby service. H.E.S.

Sintered glass absorber for determining carbon by wet combustion. P. A. WELLS, O. E. MAY, AND C. E. SENSEMAN. *Ind. Eng. Chem., Anal. Ed.*, **6** [5] 369–70 (1934).—A sintered glass absorber is described which has several advantages over the glass-bead absorber previously used for this determination. It is unnecessary to maintain a large excess of alkali, and consequently the method has a wider range of application. Washing the alkali from the absorber is easier. Difficulties due to the disintegration of the glass beads by the alkali are eliminated. F.G.H.

Surface temperature of a body. TOYOFUJIMARU YOSHII. *Jour. Jap. Ceram. Assn.*, **43** [510] 352–57 (1935).—Descriptions and discussions are given on various methods of measuring the surface temperature of bodies. In 1931, Y. proposed a method of measuring the correct temperature of the shell of a rotary kiln: $L(t_1 - t_2)\alpha = l$, where L = length of kiln at room temperature, t_2, t_1 = mean temperature of shell in working, α = coefficient of linear expansion of shell, and l = elongation of shell. Y. proposes the surface-temperature scale method, in which the temperature is detected by fusion, ignition, or color change of the substance applied on the surface. A series of substances should be selected like that of pyrometric cones. S.K.

PATENTS

Automatic fuel-feeding apparatus for annular ceramic kilns. WILHELM ERNST SPAETHE. Ger. 610,219, March 6, 1935; *Chem. Abs.*, **29**, 3798 (1935).

Ceramic furnace partitioned by a column of sand or like material. KERAMISCHE INDUSTRIE-BEDARFS A.-G. Ger. 609,009, Feb. 6, 1935; *Chem. Abs.*, **29**, 3128 (1935).

Device on brick kiln for utilizing the heat of the fired brick for preheating and drying. A. G. BERN. Swed. 79,716, Feb. 27, 1934; *Chem. Abs.*, **29**, 3481 (1935).

Electric furnace. A. H. HEYROTH AND J. I. MILLER (Globar Corp.). U. S. 2,007,605, July 9, 1935 (Jan. 16, 1931).—A furnace for the heat treatment of ceramic objects comprises a heating chamber, electrical heating resistors within the chamber, a removable cover from which objects to be heat treated are supported in vertically downward position by attachment of their upper ends to the cover, and a screen of refractory rods interposed between the electrical resistors and the ceramic objects under heat treatment.

Electric furnace for firing ceramic articles. GES. FÜR ELEKTRO-HEIZUNGSTECHNIK M. B. H. Austrian 140,753, Feb. 25, 1935; *Chem. Abs.*, **29**, 3798 (1935).

Electrically heated tunnel kiln with traveling hearth. LUDWIG RIEDHAMMER. Ger. 611,495, March 28, 1935; *Chem. Abs.*, **29**, 4146 (1935).

Firing or glazing ceramic articles. PORZELLANFABRIK PH. ROSENTHAL & CO. A.-G. Ger. 611,234, March 25, 1935; *Chem. Abs.*, **29**, 4146 (1935).—A furnace is described in which, to insure uniform heating, the articles under treatment are rotated around a horizontal axis. The furnace is intended particularly for the treatment of electrical resistances comprising a wire wound on a ceramic support.

Firing porcelain. MAX HOLLENWEGER. Ger. 606,730, Dec. 8, 1934; *Chem. Abs.*, **29**, 3798 (1935).—In firing porcelain made of a mixture of clay, glass-forming substances such as quartz or feldspar, and a flux, the melting point of the glass-forming constituents is determined and the firing carried out at this temperature.

Method for converting carbon dioxide contained in gases into carbon monoxide. OTTO STÅLHANE AND J. B. STÅLHANE. U. S. 2,007,586, July 9, 1935 (Sept. 22, 1931). A process for converting carbon dioxide present in gaseous mixtures into carbon monoxide comprises passing the gaseous mixture together with finely divided carbon through a chamber having heated walls and into contact with a plurality of electrical heating devices having a temperature of at least 1100°C adapted to supply part of the heat necessary for causing the carbon to react with the gaseous mixture to effect the conversion.

Rotary internally fired kiln. A. W. HEYMAN. U. S. 1,953,856, April 3, 1934 (May 27, 1931); *Brit. Chem. Abs.*, **54** [1] 2*B* (1935).—Hollow metallic elements are attached to the interior of the shell and cooling currents of air or H_2O are permitted to flow through them by means of openings in the shell. A refractory lining is wedged between the elements and over them, the portion radially inward of the elements being preferably of aluminate cement. A coating of the material under treatment may also be allowed to congeal on the lining.

Temperature-regulating device for electric furnaces, air heaters, drying chambers, etc. SIEMENS-SCHUCKERTWERKE A.-G. Ger. 609,487, Feb. 15, 1935; *Chem. Abs.*, **29**, 2791 (1935).

Tunnel kiln for firing ceramic ware. C. OTTO & CO. G.M.B.H. Ger. 607,657, Jan. 5, 1935; *Chem. Abs.*, **29**, 4146 (1935).

Geology

Artificial cryolite. P. FERRAZZI. *Centro Studi Ceram.*, **2** [4] 46 (1935).—Artificial or synthetic cryolite is cheaper than natural cryolite, which is mined mostly in Greenland and purified in Denmark. It is used in enamels and glasses to lower the fusing point of the glass mass; it increases elasticity and resistance to shock, lessens contraction, and is an excellent opacifier. M.V.C.

Basic magnesium carbonates. L. W. LEVY. *Compt. rend.*, **200** [23] 1940–42 (1935).—Besides the only known basic Mg carbonate, the hydromagnesite, $5MgO{\cdot}4CO_2{\cdot}5H_2O$, two new basic compounds have been established; magnesia, $Mg(OH)_2$, and giobertite, CO_3Mg. Preparation and properties are described. M.H.

Bleaching clays. F. H. CAMPBELL. *Chem. Eng. Mining Rev.*, **27** [315] 92–94 (1934).—The importance of bleaching earths in the oil, textile, and other industries is stressed, and the method of preparing a clay for bleaching purposes is described. H.H.S.

Ceramic properties of northern Ontario metal mine tailings. A. E. R. WESTMAN. *Jour. Can. Ceram. Soc.*, **4**, 42–44 (1935).—A number of towns in northern Ontario depend almost entirely on the metal mining industry; they would be benefited materially if other industries could be established. The metal mines produce large quantities of tailings or finely ground mixtures of nonmetallic minerals which are not utilized; in fact, their disposal is frequently a problem. The Ontario Research Foundation has undertaken an investigation of possible uses for these tailings. This paper is a progress report on their use in ceramic bodies. By a suitable choice of composition and firing procedure, metal mine tailings can be used to produce ceramic ware having a wide range of color and porosity. With bodies containing high proportions of tailings, reducing conditions might be necessary to produce dense ware. J.G.P.

Chrome-ore mining of the world. WALTER GÜNTHER. *Z. prakt. Geol.*, **42** [7] 97–104 (1934).—Data are given on chrome-ore deposits of the world, their average composition, mining, and export and import by various countries. M.V.C.

Constitution and origin of leverrierite. J. DE LAPPARENT. *Compt. rend.*, **198** [7] 669–71 (1934).—Leverrierite is considered to be a combination of muscovite and kaolinite; an exact definition of the structure can not be given except that the one constituent is regularly oriented with reference to the other. M.H.

Definition of sepiolites. H. LONGCHAMBON AND GEO. MIGEON. *Compt. rend.*, **200** [23] 1946–49 (1935).—Sepiolite occurs in several modifications which can be represented by the general formula Si_4O_{11} $(Mg,H_2)_3 \cdot 1H_2O \cdot (H_2O)z$; z corresponds to the amount of water and was determined numerically for six minerals to between 3.2 and 5.2. Mg (in this formula) means Mg + Ca + Fe. Physicochemical properties are described. M.H.

Dumortierite-andalusite mineralization at Oreana, Nevada. PAUL F. KERR AND PHILIP JENNEY. *Econ. Geol.*, **30** [3] 287–300 (1935).—The geologic history of the dumortierite deposit located in Humboldt Queen Canyon five miles east of Oreana is considered. The dumortierite-andalusite deposit occurs in two parallel zones, each about 75 ft. wide. The owners, Champion Sillimanite, Inc., have taken over 2500 tons of dumortierite ore from the deposit for use in spark-plug cores and chemical laboratory porcelain. Due to the high boron content it has properties valuable for high-grade refractory porcelain. It may be changed to mullite by calcination, as may be andalusite, kyanite, and sillimanite. The ore occurs in three generations: (1) as coarse euhedral, blue crystals, (2) as matted lavender or pink masses, and (3) as fibrous pink veins or isolated pink crystals. The majority of the ore mined is of the second variety. Andalusite, quartz, albite, and sericite occur abundantly with the dumortierite. From the manner of the association of the andalusite with each generation of the dumortierite, the latter appears to be later in formation than the andalusite. From the manner of the occurrence and from the abundance of the andalusite, it appears that a process for its recovery could be worked out profitably. J.L.G.

Experimental tests on quartz and china clay. R. K. CARNOCHAN AND R. A. ROGERS. *Can. Dept. Mines, Mines Branch, Rept.*, No. 736, pp. 240–43 (1932).—Nine lots of china clay and quartz from Lac Remi, Que., were investigated. The purposes of the investigation were (1) preparation of quartz for use in glassmaking and sandblasting, (2) preparation of china clay, (3) preparation of quartz for ceramic purposes, and (4) separation of dark clay from quartz for ceramic use. Washing, tabling, and sizing gave 47.5% of lot No. 1 and 22.3% of lot No. 2 as sand suitable for making clear glass, and washing and tabling gave 71.1% of lot No. 3. It is believed that if sand is not over 0.06% Fe_2O_3, a little SiO_2 is not objectionable for clear glass. If this is true, the quartz could be used for clear glass by crushing and removal of clay and fines. The first two lots of silica ground to 200-mesh for ceramic use did not give good firing tests. The third lot seemed better, and the silica may have a ceramic use. The silica will make a fair blast sand. The clay recovered from lots Nos. 1 and 2 was buff in color; lot No. 7A, however, which was clay removed at Lac Remi from the quartz, has better color and this clay will probably have a ceramic use. The air-separation tests show that if there is coarse in the feed, a small amount of it will go into fines. Rolls and a rod mill would be suitable machines to reduce the quartz to 20-mesh with a minimum of fines, but a pebble or ball mill would not. J.G.P.

Feldspars. V. C. *Verre & Silicates Ind.*, **6** [7] 134–35 (1935).—The feldspar deposits in the Pyrenees and the increasing development of the industry, especially at Caudiés-de-Fenouillédes, are described. M.V.C.

High-temperature mineral associations at shallow to moderate depths. A. F. BUDDINGTON. *Econ. Geol.*, **30** [3] 205–22 (1935).—The possible combinations of temperature and pressure in the formation of minerals are listed, and the classes of deposits which fall under the different headings are mentioned. Mineral associations interpreted as formed at high temperatures are discussed in detail with reference to specific minerals and deposits. J.L.G.

Lignite and refractory clay deposits of the Onakawana lignite field. W. S. DYER AND A. R. CROZIER. *Ontario Dept. Mines Ann. Rept.*, **42** [Part 3], 47–78 (1933).—This report gives the results of all the exploratory and investigational work carried out on the lignite deposits in this area since May 31, 1930. In addition to the latter work, the report gives the most recent conception of the geology of the field as based upon it. Refractory clay deposits are also described. J.G.P.

Lithium in Australia. ANON. *Chem. Eng. Mining Rev.*, **27** [315] 84 (1934).—Li, which has been found to confer valuable qualities on industrial metals, occurs as lepidolite, amblygonite, and spodumene at Ravensthorpe, Wodgina, and other places in W. Australia. H.H.S.

North Carolina talc deposits. J. L. STUCKEY. *Jour. Elisha Mitchell Sci. Soc.*, **50**, 41–42 (1934); *Chem. Abs.* **29**, 1365 (1935).—Talc deposits in Macon and Cherokee Counties, N. C., are associated with marble. They were probably formed by hot solutions from quartz-diorite dikes after metamorphism of the sediments and not by simple metamorphism of the $MgCO_3$ in the original limestone.

Pottery clays and methods of testing them. ARTHUR RIGBY. *Pottery Gaz.*, **60** [697] 884–86 (1935).—R. refers

to misconceptions current in the pottery industry on testing clay samples. No definite mixture of clays is recommended for specified bodies as this can be determined only in the factory under normal working conditions, where attention is given to methods of shaping, types of ware made, drying and firing conditions, and type of glaze used. More attention should be given to the testing of clays according to their blend with other clays. E.J.V.

Quartz. G. H. McINTYRE. *Enamelist*, **12** [9] 30–34 (1935).—The various forms of silica are plentiful, the crystalline form, quartz, being the most common. The forms in which quartz is found are listed. Methods of preparing quartz for the ceramic industry are described. A silica flow sheet from deposit to consumer is presented. E.J.V.

Refractory clay deposits on the Missinaibi River. A. R. CROZIER. *Ontario Dept. Mines Ann. Rept.*, **42** [Part 3], 88–101 (1933).—An intensive survey of the Missinaibi and its tributaries was made to ascertain the commercial possibilities of the refractory clays in this area. About 50 samples were taken of clay and sandy kaolin. Fusion cone tests were run on 32 of the samples, of which 25 were over cone 30. The preliminary survey definitely indicated two promising deposits of refractory clay. Their outstanding features are the uniformly high P.C.E. of the clays and thickness and length of exposures. Although no definite estimate of the tonnages of the deposits can be given, the possibility of blocking out commercial quantities are good. The moderate thickness of overburden compares favorably with other clay deposits in the Moose River basin. Pits and auger holes at the Ruby-Sheppard claims (location *B*) penetrated to 24½ ft. of very refractory clay (cones 30 to 25) and bottomed in it. Nearly every auger hole reached the clay when augering operations were suspended. The benches or terraces along the river bank at these claims afford an excellent opportunity for a small-scale stripping operation. The clay exposures are numerous and extensive. The refractory clay occurrences at the Tees-Curran claims (location *D*) are extensive but not thick, the maximum thickness being 9 ft. The fusion cones of the clay run from 29 to 32. The bottom of the clay seam is well above river water-level and lends itself to easy and cheap recovery. The successful development of these deposits will depend on the possible uses for this type of refractory clay and the solving of the transportation problem. The primary commercial possibilities occur on the Missinaibi or its tributaries. The deposits located were of the red and gray mottled refractory-clay type with occasional seams or lenses of white refractory clays; these are thin and irregular and could only be worked in conjunction with the red and gray mottled clays. See also *Ceram. Abs.*, **12** [8] 301 (1933). J.G.P.

Titanium products from Tasmania. ANON. *Chem. Eng. Mining Rev.*, **27** [314] 57 (1934).—Ilmenite from Tasmania is worked at Melbourne by the Laporte process for the manufacture of Ti white, etc. H.H.S.

Zirconium and its derivatives. MAURICE DÉRIBÉRÉ. *Rev. mat. constr. trav. pub.*, No. 307, pp. 61–63*B* (1935).—The discovery and isolation of the metal, zirconium, are given briefly. The compounds, properties, uses, and application in industry of zirconium and its minerals are described together with world deposits of the different forms of the minerals. M.V.C.

Zirconium and its uses. L. SANDERSON. *Sands, Clays & Minerals*, **2** [3] 47–50 (1935).—Deposits of Zr ores, methods of extraction, sources of supply, and the present inextensive use of Zr are reviewed and physical properties are described. At present it is used chiefly as ferrozirconium; production methods are described. Zr is said to insure sound castings and to increase strength and resistance to acids. Claims made for Zr steels to have better mechanical properties have not been substantiated. M.H.

Zirconium-pyrophosphate. ADRIEN KARL. *Compt. rend.*, **200** [20] 1668 (1935).—The mineral, $P_2O_7Zr{\cdot}2H_2O$, is very weakly soluble in concentrated acids but readily soluble in concentrated, boiling solutions of alkaline carbonates. Pure Zr can be easily prepared from it in the presence of Fe and Ti; the method is briefly described. M.H.

Chemistry and Physics

Basic open-hearth process. J. M. FERGUSON. *Jour. West Scot. Iron Steel Inst.*, **42**, 13–23 (1934); *Chem. Abs.* **29**, 2123 (1935).—The identification of the constituents in cold slag is an essential preliminary to knowledge of the constitution of molten slag. Slag crystals large enough for chemical analysis were isolated from masses of 10 to 12 tons of slowly cooled slag to which small quantities of moist slag of the same general composition had been added. Basic slags differ from acid slags in that they contain no glassy base. One of the most commonly occurring constituents is tribasic ferrite, $3CaO{\cdot}SiO_2$ (I), which forms at an early stage of solidification. The magnetic constituent (II) is apparently an unstable combination of CaO and Fe_2O_3 containing a large amount of MnO; its amount is very low until the later finishing stages. Crystals of magnetite have never been observed in basic slags. The last constituent to solidify is tricalcic silicate (III), crystals of which contain many symmetrically arranged inclusions identified as I, II, and fluorapatite. The R_2O_3 of the slag is present in these inclusions in combination with lime. Dicalcic silicate is characteristic of basic slags of higher silica content and low ferric Fe. The composition and the characteristics of these constituents in ordinary and polarized transmitted light are reported. The presence of crystalline constituents in rapidly chilled slags proves that the components of these crystals must have combined in the liquid slag. The data obtained from slowly cooled slags are applied to rapidly cooled process slags. The results of complete chemical and petrographic examinations are given for a series of 19 samples taken at regular intervals from a heat that finished at 0.05% C. Tribasic finishing slags are preferred and are favored by high temperatures. Oxidation by the furnace gases increases with slag acidity and low bath temperature.

Chemical constitution of natural silicates. E. ONORATO. *Rend. seminario facoltà sci. univ. Cagliari*, **2**, 25–30 (1932); *Chem. Zentr.*, **i**, 3300 (1933); *Chem. Abs.*, **28**, 6088 (1934). —The structure of various ortho-, meta-, di-, and tri-

silicates was studied and the following formulas are offered: kyanite, sillimanite, andalusite, $Al_2O(SiO_4)$; nosean (noselite), $Na_6(Al_6Si_6O_{24})\cdot 2Na_2SO_4$; hauyne (hauynite), $Na_6(Al_6Si_6O_{24})\cdot 2(Na_2\cdot Ca)SO_4$; lapis lazuli, $Na_6(Al_6Si_6O_{24})\cdot 2Na_2S_3$; cordierite, $Mg_2(Al_4Si_5O_{18})$; orthoclase, $K(AlSi_3O_8)$; anorthite, $Ca(Al_2Si_2O_8)$; albite, $Na(AlSi_3O_8)$; talc, $(OH)_2Mg_3(Si_4O_{10})$; pyrophyllite, $(OH)_2Al_2(Si_4O_{10})$; phlogopite, $(OH)_2KMg_3(AlSi_3O_{10})$; muscovite, $(OH)_2KAl_2(AlSi_3O_{10})$; margarite, $(OH)_2Ca_2Al_2(Al_2Si_2O_{10})$.

Colorimetric standards for silica. H. W. Swank and M. G. Mellon. *Ind. Eng. Chem., Anal. Ed.*, **6** [5] 348–50 (1934).—From a study with the spectrophotometer, possible standards are proposed for use in determining small amounts of dissolved silica by the method which depends upon the formation of a yellow heteropoly compound, molybdisilicic acid, by the reaction of ammonium molybdate and the silica in the presence of a mineral acid. F.G.H.

Crazing and peeling of glazes. J. W. Mellor. *Trans Ceram. Soc.* [Eng.], **34** [1] 1–112 (1935).—M. deals extensively with and elucidates the general principles underlying the reversible phenomenon of crazing and peeling. The more important topics considered are (1) coefficients of thermal expansion of body and glaze, (2) mechanics of crazing and peeling, (3) viscosity of glazes, (4) interface between glaze and body, (5) influence of the porosity and texture of the body on crazing, (6) effect of calcination on the nature of silica, (7) effect of variation in composition on the soundness of a glaze, (8) crazing of glazed tile in service, and (9) tests for crazing. Bibliography. Illustrated. R.H.H.P., Jr.

Determining aluminum in bauxites by rapid method. S. S. Zhukovskaya, S. S. Bernstein, and S. T. Baluik. *Legkie Metallui*, **3** [3] 25–29 (1934); abstracted in *Chem. Zentr.*, **i**, 757 (1935).—Five cubic centimeters of 50% NaOH are heated in an Ag-crucible; after cooling, 0.1 g. of air-dried bauxite is added and the mixture is carefully heated up to the end of the gas-bubble development and the appearance of reddish-brown coloring. The crucible is put over a water or sand bath for several minutes; the contents are poured into a beaker and washed with boiling water. The solution is heated to boiling, filtered, and washed with a boiling solution of 3% NaCl and 5% NaOH. The filtrate is treated with HCl up to the dissolving of the Nd precipitated, 40 cc. of a 1.5% solution of "Oxin" combined with HCl are added, the whole is cooled, and 3 to 4 g. Na-acetate are added. It is heated over a water bath until the appearance of crystallized Nd, cooled, and filtered; Nd is washed with a 2% Na-acetate solution until the disappearance of the yellow color. Nd and the filtrate are dissolved in 90 cc. HCl, cooled, and diluted with water; several drops of 1% indigo-carmine solution are added and titrated with 0.2 *N* KB_3-KB_2O_3 solution until the color changes from blue to yellow. The flask is covered with a watch glass, and 5 to 7 cc. 10% KI-solution are added; the solution is stirred, and the I_2 precipitated is titrated with 0.2 *N* $Na_2S_2O_3$ solution and 3 to 4 cc. 1% starch solution. The determination of Fe is also considerably accelerated when using the NaOH melt. M.V.C.

Durability of pottery frits, glazes, glasses, and enamels in service. J. W. Mellor. *Trans. Ceram. Soc.* [Eng.], **34** [2] 113–90 (1935).—M. deals extensively with (1) effects of various corrosive agents such as water, acids, alkalis, and gases which glasses, glazes, and enamels are likely to meet in service, and (2) favorable or unfavorable effects of the constituents of glasses, glazes, and enamels on the resistance to attack by these deleterious agents. Bibliography. Illustrated. R.H.H.P., Jr.

Effect of magnesia on the synthesis of tricalcium silicate. Seiji Kondo and Matsunosuke Higuchi. *Jour. Jap. Ceram. Assn.*, **43** [509] 273–80 (1935).—Mixtures composed of 100 parts of $3CaO\cdot SiO_2$ and 0 to 6 parts of MgO were heated 1 to 4 times at 1500°C for 90 min. The chemical composition of the products indicated that the formation of tricalcium silicate was accelerated by the presence of magnesia, that its effect increased with its increasing amount, and that the repetition of the heating and pulverization favored the formation of the silicate. The results were verified by microscopic examinations and X-ray analyses. An attempt to determine free magnesia by a combination of Rathke's method of determining free lime and the method of N. A. Tananaeff and L. M. Kuehlberg for determining free lime and magnesia was not successful. S.K.

Occlusion of water by potassium and sodium chlorides. Influence on indirect determination of sodium. G. Frederick Smith, F. M. Stubblefield, and E. B. Middleton. *Ind. Eng. Chem., Anal. Ed.*, **6** [5] 314 (1934). F.G.H.

Photocolorimetric determination of silica in the presence of phosphoric acid. M. Cerny. *Chem. Obzor*, **9**, 121–22, 138–40 (1934); abstracted in *Chem. Zentr.*, **i**, 600 (1935). M.V.C.

Plasticity of crystals. Pol Duwez. *Phys. Rev.*, **47** [6] 494–501 (1935).—D. develops a theory establishing a mathematical relationship between the stress and the strain in a crystal when it is plastically deformed. The existence of a secondary "structure," pointed out by F. Zwicky (*Ceram. Abs.*, **13** [1] 25 (1934)) as a consequence of "coöperative phenomena," is accepted as a basic postulate. Assuming that gliding in crystals occurs between blocks of the secondary structure, D. considers a statistical distribution of the different forces which produce gliding between the blocks. As a final result, a stress-strain curve for a crystal is secured which is an exponential law containing three constants, the torsional modulus, the elastic limit, and the maximum applicable stress. The form of the hysteresis cycles is deduced from the same considerations, and a formula is obtained for the areas of the cycles. Experiments on a single crystal of copper and on ordinary microcrystalline copper verified the theory. J.L.G.

Solid state. R. E. Gibbs. *Sci. Prog.*, **29** [116] 661–74 (1935).—The work of Bragg, Evald, C. G. Darwin, Griffith, Joffé, Obreimoff, Andrade, 3mekal, Zwicky, G. I. Taylor, and others during the last twenty years is summarized. H.H.S.

Spectroscopic analysis. F. Pavelka and H. Molterer. *Mikrochemie*, **11**, 47–102 (1935).—The development of the spectroscopic analysis during the last 20 years has led to a method which is entirely microchemical in nature. This lengthy review and discussion should be of interest to microchemists and analytical chemists. 129 references. Illustrated. L.E.T.

Viscosity data for boron trioxide. George S. Parks

AND MONROE E. SPAGHT. *Physics*, **6** [2] 69–71 (1935).—The viscosities of four samples of pure molten boron trioxide have been measured between 267 and 443°C with a concentric cylinder viscometer. The results, representing true viscosity, range from 2.1×10^{11} to 2.1×10^{5} poises and are consistent with earlier data obtained at much higher temperatures. A viscosity value near 10^{13} to 10^{14} poises appears to be associated with the so-called transition region in this and other glassy or amorphous materials.

Viscosity data for silicate melts. N. L. BOWEN. *Trans. Amer. Geophys. Union, 15th Ann. Meeting*, Part I, pp. 249–55 (1934): *Chem. Abs.*, **28**, 7212 (1934).—Results of measurement of the viscosities of silicate melts that are of interest to petrologists are presented graphically and in tabular form.

BOOK

X-ray Crystallography. R. W. JAMES. Series of Methuen's Monographs of Physical Subjects. Methuen & Co., Ltd., London, 1930. 88 pp. Price 2s 6d. This small book deals with (1) crystal form and space-lattice, (2) crystal lattice as a diffraction grating, (3) symmetry of crystals and its determination using X-rays, (4) intensities of X-ray spectra, and (5) types of crystal structure including silicates. S. I. PERKAL

PATENT

Opacifying compounds. HARSHAW CHEMICAL CO. Fr. 776,034, Jan. 15, 1935; *Chem. Abs.*, **29**, 3482 (1935).—Opacifying compounds for enamels are made by causing Ti or Zr in a form giving an oxide, Sb oxide, and a substance giving an oxide of Zn, Ba, Cu, Be, Sn, Sr, Mg, Al, Ce, Mn, Pb, or Cu to react together. Thus the calculated amounts of Sb_2O_3 or Sb_2O_4 and TiO_2 are mixed to form a paste with a solution of $Zn(NO_3)_2$ calculated to give $2ZnO$; the paste is dried and heated for several hours to 1000°.

General

Action of harmful dusts. E. H. KETTLE. *Iron & Coal Trades Rev.*, **128** [3460] 1015 (1934).—The pathological aspects of silicosis, harmful and harmless constituents of dusts, the relation of silicosis to tuberculosis, and protective means for labor are discussed. M.H.

Ceramic special substances. H. HANDREK. *Arch. Tech. Mess.*, **4** [44] 28-29*T* (1935).—Ceramic special substances are masses which differ in their composition from that of hard porcelain, steatite, and earthenware but are handled in the same manner and produced by the same manufacturing processes. They are weatherproof, resist tropical climates, humidity, and alkalis and acids (except HF), do not burn, and stand temperatures up to 1000°C. They have low elasticity and greater rigidity than organic materials and metals. The principal representatives are as follows: (1) Clay-rich masses with dense body: sinter corundum is 99.8% Al_2O_3 and 0.2% impurities, sintered at 1800°C; Isomar is a soapstone-free alumina silicate with high Al_2O_3 content; Pyranite is a sillimanite-containing alumina silicate similar to porcelain; Pyrodur is a white, clay-rich substance, useful up to 1650°C; Pythagoras substance is highly refractory and withstands temperature changes, is very dense, and holds vacuum up to 1580°C. (2) Magnesium-silicate substances with dense body, *i.e.*, Calit, Calan (Ger. 552,750, *Ceram. Abs.*, **14** [1] 26 (1935)), Ultracalan (Ger. 591,090, *Ceram. Abs.*, **13** [10] 265 (1934)), and Frequenta. Their composition is approximately $3MgO{\cdot}4SiO_2{\cdot}H_2O$, to which talc, soapstone, or magnesium oxyhydride are added. (3) Clay-magnesium silicate masses with dense body; they are usually ternary compounds of MgO–Al_2O_3–SiO_2 with additions of K_2O or Na_2O. These masses have a low thermal-expansion coefficient; their trade names are Ardostan and Sipa. (4) Dense substances with high content of titanium compounds, Condensa and Kerefar. They contain chiefly TiO_2 which has been transformed by the ceramic process from the amorphous into the crystalline state; they have a high dielectric constant. (5) Porous special substances of the system MgO–Al_2O_3–SiO_2, Magnesolite and Thermisol, are similar to earthenware. (6) Clay-rich porous special masses (they are considerably more refractory than group 5). Rheostite and Calodur contain corundum, are good heat conductors, and are used as heating elements in which the electric wires or strips are imbedded. They can be used up to 1000°C. (7) Special substances of oxides of Be and Zr and of silicon carbide, etc. A table of mechanical, electrical, and thermal properties, and of manufacturers is added for each group. Fourteen references. M.H.

Experimental silicosis. W. GIESE. *Beitr. pathol. Anatom.*, **94**, 442–90 (1935); *Ind. Hygiene Abs.*, **17** [4] 81–82 (1935).—G. injected quartz dust (particle size of 1 to 10μ), suspended in physiological salt solution, intravenously into rabbits several times a week over a period of 20 months. He then studied exhaustively the changes in the liver, spleen, bone marrow, and lymph glands. In these organs marked changes with considerable fibrosis were found, while in the lungs silicotic nodules could not be shown during the period of this study. The changes caused by barite, in experiments lasting 19 months, were much less than those in the quartz-dust study. The impression was also gained that the organs contained less dust, which must, therefore, have disappeared in some manner from the animal. In experiments with calcite, it was shown that this was destroyed in the body even to the smallest trace. Gardner obtained the same results with Carborundum. With clay, no fibrosis was found in the same period of observation, but the dissolving-out process (resulting in induration, or cell destruction) was also completely lacking. Most probably the silicate groups (SiO_4 and SiO_3) have the same action as clay. For the other silicates, the deviating characteristics of one of the group must first be determined. Further experiments are necessary. Experiments with mixed dusts gave no evidence that dust mixed with quartz delayed the action. Quartz remains in old silicotic nodules while other dusts, such as carbon, disappear. The extensive solution of the quartz particle is only a theoretical hypothesis which stands in opposition to the evidence given. E.J.V.

Mineral residues of silicotic lungs. A. B. EDWARDS. *Chem. Eng. Mining Rev.*, **27** [316] 125 (Jan., 1935).—Work by Melbourne doctors on Australian miners confirms overseas results on the pernicious effects of sericite, etc. H.H.S.

Pneumoconiosis. J. G. CUNNINGHAM. *Jour. Can. Ceram. Soc.*, **4**, 17–18 (1935).—Pneumoconiosis, particularly in the ceramic industry, is discussed as to causes, statistics, and methods of elimination. J.G.P.

Prevention of silicosis. Z. WIRTSCHAFTER. *Ind. Medicine*, **4** [2] 65–66 (1935); *Ind. Hygiene Abs.*, **17** [4] 82 (1935)—W. discusses Mavrogordato's "critical levels" of dust concentration (A ranging from 20 mg./cu. m., B equal to 5 to 20 mg./cu.m., and C equal to 1 to 5 mg./cu. m.) which serve as excellent indices of health conditions. In mining operations, there are income dust (produced by rock-drilling) and capital dust (that which is always circulating in the mines). Income dust may be controlled by wetting, increased air dilution, and blasting only once in 24 hours; capital dust is minimized by good ventilation, segregation of dust-producing processes, exhaust systems, and respirators. Medical supervision is of great value. Periodic dust counts should always be made. W. points out that in using the wet method of dust control, there is a danger of spreading tubercle bacilli by water droplets. E.J.V.

Purification of clay by electroösmosis. ANON. *Verre & Silicates Ind.*, **6** [7] 121–23 (1935).—Iron and other impurities in second-rate kaolins can be removed by electroösmosis on a scale sufficiently large to make the treatment worth while and economical in certain cases. Figures show the considerable reduction in the silica and iron oxide content of a kaolin treated in the apparatus of the Electro-Osmose Society. Similar apparatus has been used to purify bauxite, although not commercially as in the treatment of kaolin. M.V.C.

Shop control of injurious dusts. J. W. BROWN. *Jour. Can. Ceram. Soc.*, **4**, 19–20 (1935).—Protective measures against the dust hazard instituted at the Moffat Stove Co., Weston, Ont., are as follows: (1) Suction equipment is in action at the source of dust production. (2) All workers exposed to dust are issued a dust mask (as their personal property) and extra facelets; this enables the worker to keep a clean facelet on his mask at all times and helps to prevent the mask from chapping. The sandblasters wear a Pangborn water-washed helmet, which supplies the operator with moistened fresh air. (3) Dust is not allowed to accumulate on the floors of enameling or sandblasting departments and is removed by means of water hosing and wet sweeping. (4) Dust is removed from places of lodgement periodically. (5) The lunch rooms are separate from the work rooms and are kept clean by water hosing. (6) A shower of hot and cold water is convenient at all times. (7) All workers are encouraged to coöperate by (*a*) avoiding constipation, (*b*) personal cleanliness, (*c*) washing hands and cleaning enamel from fingernails before eating, (*d*) keeping each worker's area of working space in order, and (*e*) avoiding unnecessary dust production. (8) Workers are advised that lead dust has a tendency to create an anemic condition and are instructed to secure plenty of fresh air and, if possible, to eat blood-producing foods. (9) All workers are given a thorough examination by the company doctor once a year. If the test reveals even preliminary indications of ill health, the worker is removed to an occupation free from dust, is supplied with medicine daily, and returns for medical examinations every three months until reported in good health. The sandblasters' examination includes X-ray every six months. (10) The doctor's report, showing results of each examination, is carefully checked and a health record of each individual is kept on file. J.G.P.

Silicosis. WILLIAM D. MCNALLY AND W. L. BERGMAN. *Ind. Medicine*, **4** [2] 61–65 (1935); *Ind. Hygiene Abs.*, **17** [4] 81 (1935).—The entire subject is discussed historically, the signs and symptoms, diagnosis, prognosis, pathology, and methods of collecting dust. Summarizing: (1) Silicosis is not a new disease, but has been brought into prominence by the period of unemployment. (2) A complete survey and dust counts should be made of every industrial plant to minimize the hazard. (3) Silicon dioxide is a common constituent of the air we breathe, the food we eat, and the water we drink; it is found in all tissues of the body. (4) The theory is advanced that fibrosis in silicosis is produced upon the silica by chemical action of sodium fluoride in blood upon the silica. Silicon dusts become more harmful as the amount of sodium fluoride is increased in the dust. (5) A chemical examination of normal and silicotic lungs is given. E.J.V.

Silicosis (discussion). A. J. ORENSTEIN. *Jour. Chem. Met. Mining Soc. S. Africa*, **35**, 209 (1935); *Ind. Hygiene Abs.*, **17** [4] 80–81 (1935).—In commenting on Jones' theory (*Ceram. Abs.*, **14** [3] 84 (1935)) that sericite, and not silica, is the dominant cause of silicosis, the following points are given: (1) Inferences drawn from alleged absence of silicosis under certain conditions of exposure to certain dusts have proved fallacious, and workers are cautioned against reports that no silicosis occurs where siliceous dust in heavy concentrations is present. (2) Sericite may cause silicosis; pure silica undoubtedly does. Workers at the Banting Institute of Canada have shown that in laboratory animals, silica caused silicosis when sericite did not. (3) It is doubtful whether it is possible to distinguish under the petrological microscope very fine particles of silica from those of sericite. (4) The presence of a certain foreign substance in dead silicotic lungs is no proof that this particular substance is the dominant cause of the morbid process. (5) Facts resulting from intensive experimental work are required. E.J.V.

Silicosis in industry. EDGAR MORTON. *Sands, Clays, & Minerals*, **2** [3] 81–83 (1935).—The occurrence of silicosis and the degree to which the workers are exposed in various dust-developing industries are discussed with particular reference to the British Workmens' Compensation Act. The definition of silicosis is still considered to offer difficulty in its application. M.H.

Silicosis and tuberculosis in the ceramic industry. R. MITZCHERLING. *Arbeitsschutz*, pp. 132–34 (1934); *Chimie & Industrie*, **33**, 74 (1935); *Chem. Abs.*, **29**, 3125 (1935).

Urinary excretion of silica by persons exposed to silica dust. J. J. BLOOMFIELD, R. R. SAYERS, AND F. H. GOLDMAN. *U. S. Pub. Health Repts.*, **50**, 421–24(1932); *Chem. Abs.*, **29**, 3745 (1935).—The amounts of Si found in the urine of anthracite coal workers varied from 0.6 to 11.7 (average 2.5) mg./100 cc. Normal individuals excreted only an average of 1.0 mg./100 cc. A close correlation was found between the Si-dust exposure of these men for a specified number of years and the amount of urinary Si. A study of former anthracite coal workers showed that even after a lapse of several years away from any Si-dust

exposure, an increased amount of Si was being excreted by them.

BOOKS AND BULLETINS

Accuracy of manometry of explosions. General survey of the problem and comparison of piston-type with diaphragm-type manometers. H. F. COWARD AND M. D. HERSEY. *Bur. Mines Rept. of Invest.*, No. 3274, 39 pp. Free. R.A.H.

Review of literature on effects of breathing dusts, with special reference to silicosis. II. D. HARRINGTON AND SARA J. DAVENPORT. *Bur. Mines Information Circ.*, No. 6840, 49 pp. Free. For Part I see *Ceram. Abs.*, **14** [8] 203 (1935). R.A.H.

Fundamentals and economics in the clay industries. ELLIS LOVEJOY. Randall Publishing Co., Wellsville, N. Y. 1935. ii + 361 pp. Price $4.00. Foreign postage 50 cents extra. This is one of the most instructive and easily read books on ceramic technology published in English. L. simply chats with his fellow clayworkers, yet he uses scientific concepts and terminology to explain each point discussed. It is a treatise on practical clayworking problems and yet a treatise on ceramic science; it deals with ceramic technology. "We doubted if it could be done but it has been done" and "we do know and at times have doubts" express Lovejoy's humility, which he can afford to have for he has a rare understanding, based on experience and study. One can readily subscribe to his theory of plasticity, p. 43, "Such do we conceive to be plasticity, infinite surface of a highly absorptive mineral, water lubricant, water surface tension, and undoubtedly gravitational attraction between the grains of the mineral. Only when the mineral grain is fine enough to make these acting forces dominant can we have plasticity. Adsorbed salts play an important part in plasticity characteristics, stickiness, coagulation, and deflocculation." On p. 102, L. explains why chemical analysis, even the so-called rational analysis, is of doubtful use and why mineralogical analysis is better for determining the value of a clay. He could have given more emphasis to rate of vitrification and other physical characteristics as means of determining the value of a clay. L.'s experience and data do not lead him to say (p. 179) that the volume shrinkage of a stiff-mud brick equals the volume of "shrinkage water" and that the volume of water remaining in the brick equals the volume of the "pores" as determined by kerosene soaking as is the case with most, if not all, clays; yet his explanation of the physics of drying is excellent in spite of his modest confession (p. 180) "shrinkage gets us pretty deeply into trouble. The depth in fact is over our head." While L.'s enthusiasm over the possibilities of mechanical stoking of periodic kilns (p. 221) is wholly misspent, his discussions of kilns and kiln firing are excellent. "We cannot say so much in so few words," is L.'s comment (p. 242) on Morris' statement that "by taking a reasonable amount of time in making the heat, allowing air to pass over the fires, and gradually reducing the draft, the heat will be conveyed from the fire boxes and top of the kiln to the middle, sides, and bottom." What little knowledge there is on salt glazing has been summarized and complete instructions are given as to the way it is done. Why L. should recognize (p. 268) that it is the heterogeneous mineral content of the clay that causes variable glaze composition on a piece of salt-glazed ware and yet fall back on the erroneous and disproved explanation of crazing as a case of difference in coefficient of expansion of the glaze and of the body is not easily understood. Salt glazes usually are badly crazed because of the heterogeneity of the body, according to L. When discussing flame temperatures (p. 292), L. makes clear the too frequently ignored advantage of firing the ware with CO produced in the fire box and distributed among the kiln setting under pressure, the (p. 305) "delayed combustion" of which is the flame seen in the kiln. L.'s discussion of de-airing is worth the price of the book. His distinguishing between entrapped and occluded air (p. 336) and the important effect of the latter are timely. L.'s discussion of needs of records, prospecting of clay properties, clay mining, clay preparation, and plant arrangement and equipment, including driers and kilns is excellent and presented in easily understood terms. See also *Ceram. Abs.*, **13** [4] 89 (1934).

ROSS C. PURDY

Mine roof in the coking district of western Pennsylvania. J. W. PAUL AND L. N. PLEIN. *Bur. Mines Tech. Paper*, No. 563, 34 pp. Price 5 cents. Commendable features which have been introduced to prevent injury from falls of roof are cited. Thirty items suggested to protect further against injury from falls of roof and coal are listed.

R.A.H.

PATENTS

Bleaching clays. WM. FELDENHEIMER. Fr. 777,635, Feb. 25, 1935; *Chem. Abs.*, **29**, 4106 (1935).—Clay brought into suspension by an alkaline deflocculator is treated with SO_2 in the presence of Zn, washed, and afterward submitted to the action of an alkali and alkaline earth hypochlorite.

Filtering composition and method of making. W. C. KUPPINGER (Filtros, Inc.). U. S. 2,008,327, July 16, 1935 (May 19, 1931).—A filtering medium consists of a relatively fine-grained stone-like body composed of a quantity of silica in the form of globular sand particles and a relatively smaller quantity of powdered glass mixed therewith and fused in the mixture to form a unitary mass in which the glass binds the globular particles of sand tangentially by constituting films thereon adhering substantially only at such points of contact.

Porous ceramic objects. H. DAVIES. Brit. 430,391, July 3, 1935 (Aug. 30, 1934).

Process of making ceramic granules. LESLIE BROWN. U. S. 2,007,742, July 9, 1935 (March 10, 1934).—The process of producing dense vitrified ceramic granules of uniform density and coloring throughout comprises blunging a mixture of plastic vitrifiable ceramic material and inorganic coloring material in the absence of combustible material together with at least approximately 50% of water to form a slurry, filtering the slurry, drying the filter cake obtained, mechanically breaking the dried colored material into gravel-like granules, and subjecting the granules to heat sufficient to form vitrified granules of substantially the same shape and size.

Process of making felted mineral fiber. E. R. POWELL (Johns-Manville Products Corp.). U. S. 19,627, June 25, 1935 (Feb. 27, 1935), reissue of original U. S. 1,899,056, Feb. 28, 1933 (Aug. 24, 1928).

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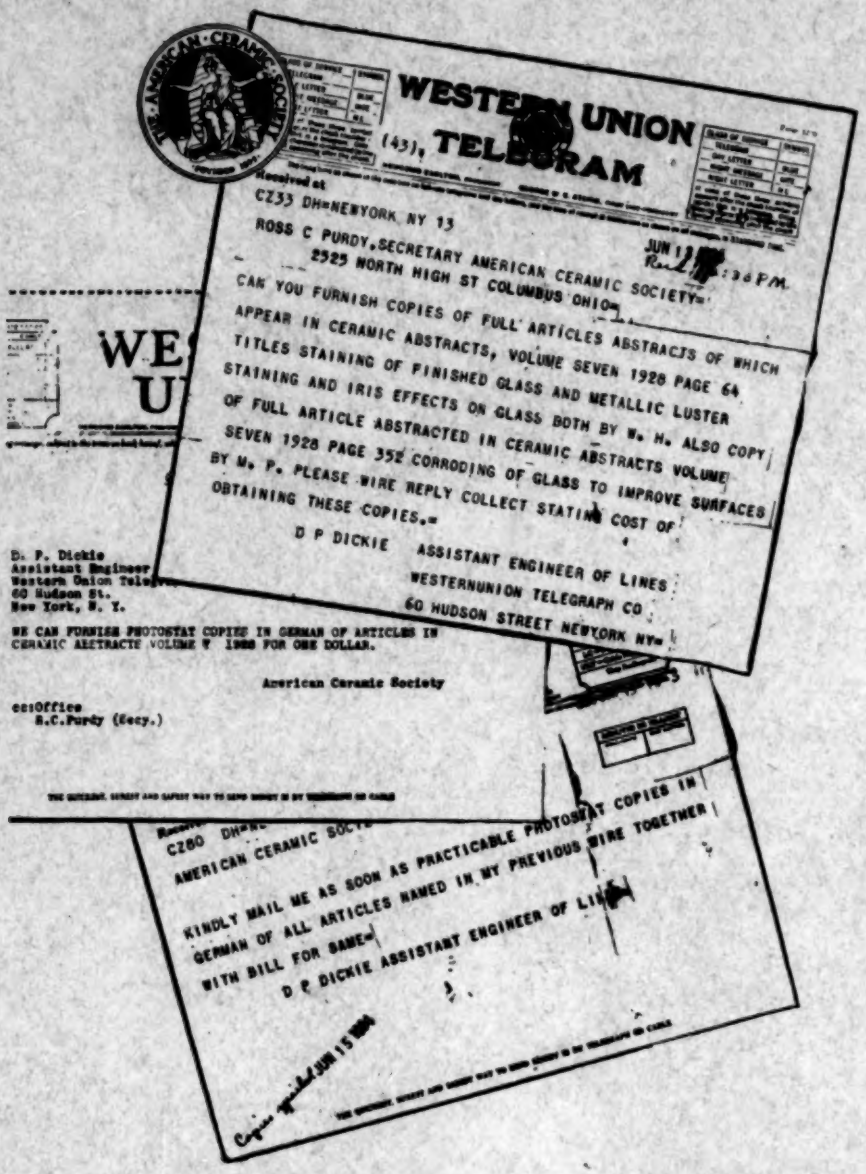
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